RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

Scaling Out Climate-Smart Agriculture for Resilient Farming

IN ADILABAD DISTRICT OF TELANGANA

Scaling Out Climate-Smart Agriculture for Resilient Farming in Adilabad District of Telangana

Project Report

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Disclaimer:

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Abstract

Climate-smart agriculture (CSA) is an important approach towards minimizing impacts due to climate risks and maintaining agricultural growth. This report is part of the project that aims to contribute towards building a national strategy for scaling out climate resilient agricultural practices and technologies by synthesizing cumulative knowledge, experiences, and learnings gained by ICAR, CCAFS, and CG Centre's Programs in climate risk management. The report outlines the process of developing a district level adaptation plan for resilient farming in the Adilabad district of Telangana by following steps of climatic risks characterization, identification and prioritization of CSA technologies and practices, the convergence of government policies and programs.

Dry spell, uneven rainfall, heat wave and cold wave frequently occur in the district with severe impact on the rainfed cropping system in the district. Location specific CSA practices have the potential to reduce the losses due to climate risk. Potential CSA technologies are categorized into six main categories of water-smart, energy-smart, nutrient-smart, carbon-smart, weather-smart and knowledge-smart. Area specific suitable CSA technologies are identified following a participatory approach through stakeholder's participation. The identified list of technology is evaluated and prioritized for implementation feasibility, acceptability, adoption barriers, synergy with government plans, incentive mechanisms and key institutions. For the implementation of these technologies at the district level, the total estimated budget was estimated to be Rs. 273.0 Crore. The convergence of resources from relevant government schemes/projects for mobilizing funds for prioritized CSA technologies has been proposed for implementing climate adaptation plans at the district level. This integrated framework will be useful for the investment decision making process for resilient farming.

Keywords

Climate-smart agriculture; climatic risks characterization, CSA practices, prioritization, stakeholder's consultation, convergence matrix, climate adaptation

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Acronyms

CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CRIDA	ICAR-Central Research Institute for Dryland Agriculture
CSA	Climate-Smart Agriculture
CSA-IF	Climate-Smart Agriculture technology Implementation Feasibility index
CSA-PI	Climate-Smart Agriculture technology Performance Index
CSV	Climate-Smart Village
CSV R4D	Climate-Smart Village - Research for Development
FYM	Farm Yard Manure
ICAR	Indian Council of Agricultural Research
ICAR-ATARI	ICAR-Agricultural Technology Application Research Institute
ICT	Information and Communication Technologies
IWMI	International Water Management Institute
KVK	Krishi Vigyan Kendra
MIDH	Mission for Integrated Development of Horticulture
NMSA	National Mission for Sustainable Agriculture
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
RADP	Rainfed Area Development Program
RKVY	Rashtriya Krishi Vikas Yojana
SAU	State Agriculture University
WBCIS	Weather based Crop Insurance Scheme

Executive Summary

Climate-smart agriculture (CSA) is an approach for transforming agriculture under the new realities of climate change. It aims to increase productivity, enhance resilience, and reduce/remove greenhouse gases (GHGs) wherever possible. For sustainable production and food security and to adapt to climate change, CSA is imperative. A new collaborative project of ICAR and CG centers "Strengthening Capacity in India for Scaling-up Climate-Smart Agriculture Technologies, Practices and Services" aims to contribute towards a national strategy for synthesizing cumulative knowledge, experiences and learnings gained by ICAR, CCAFS and CG Centre's Programs in climate risk management. This is to guide investments being made by the government and donors in scaling out climate resilient agricultural practices and technologies at the developmental scale in vulnerable agro-ecologies of India. As an outcome of the project, this report outlines the process for developing a comprehensive district climate-smart agriculture plan for resilient agriculture for Adilabad district of Telangana. District plan comprises of main steps of climatic risks characterization, identification and prioritization of CSA technologies and practices, convergence of government policies and programs for scaling out.

Climate risk characterization for longer duration of rainfall data is used to categorize the main risks occurring in district and its impact on production system. Dry spell, uneven rainfall, heat wave and cold wave frequently occur in the district with severe impact on rainfed cropping system. Drought and heat wave occurs in *rabi* and summer season respectively. Waterlogging due to shallow clay soil is also a problem in Adilabad district. These climatic risks negatively impact cropping system with crop losses, reduction in yields, flower drop, moisture stress and crop damages. To overcome these risks, climate smart/resilient agricultural technologies can play a crucial role.

Potential CSA technologies for the district are categorized into six main categories of water-smart, energy-smart, nutrient-smart, carbon-smart, weather-smart and knowledge-smart which cover agricultural production systems. Thereafter, participatory approach through stakeholder's participation is used to identify the area specific suitable CSA technologies. Identified list of technology is then evaluated for implementation feasibility, acceptability, adoption barriers, synergy with government plans, incentive mechanisms and key institutions. The prioritized technologies post analyses under different categories in Adilabad district are- water smart: farm pond, check dam, drip irrigation, mulching; energy smart: zero tillage, solar pump; nutrient smart: intercropping with legumes, use of farm yard manure, fertigation; carbon smart: concentrate feeding for livestock, bio-gas; weather smart: climate smart housing for livestock, Information and Communication Technologies (ICT); knowledge smart: fodder bank, stress tolerant high yielding variety of livestock and poultry, knowledge on bio-fertilizer and, bio pesticides, livestock management, crop diversification with fruits. The evidence on technologies from existing trials

in district show that significant gains in terms of increased production and benefit-cost ratio can be achieved. However, not all prioritized interventions evidence could be collected reflecting the gap in implementation or research on field which needs to be gathered either from similar agro-ecological zones or field trials.

The implementation of project and scaling out CSA requires financial support. The necessary assumptions based on number of villages and area covered are considered for estimating the total number of technologies. Three year averaging scenario of cropping system is taken into consideration for this purpose. The total estimated budget of Rs. 273.0 Cr. includes government assistance of Rs. 132.8 Cr. for the implementation of Adilabad district level climate adaptation plan. In Adilabad district the funds available through existing government schemes are 321.3 Cr. out of which only Mission Kakatiya scheme contributes 96% and other scheme have share of only 4%. The amount of Rs. 61.1 Cr. requires to be arranged through different technology relevant government schemes. Therefore, convergence matrix is prepared by linking the prioritized CSA technologies with relevant government schemes. This convergence matrix plays a vital role in identifying source(s) of investment required for implementing CSA technologies.

Report also briefly outlines the institutional arrangement required for implementing CSA plan and to effectively carry out the convergence. The developed district climate adaptation plan for resilient agriculture can assist in streamlining investments being made in agriculture, water and rural development sectors from various sources. The convergence and co-financing will help enhance resilience and sustainable development under changing climate scenario in the future. Also, the process and framework for developing district climate resilient agriculture plan presented in the report would provide a guidance for developing and scaling out evidence based, participatory and integrated climate adaptation plan for other districts.


BBF MACHINE

1. Project background

Maintaining agricultural growth while minimizing climate risks and shocks is crucial to building a resilient food production system and livelihood security as well as meeting development goals in vulnerable areas. Climate-smart agriculture aims to increase sustainable agricultural production by building climate resilience, increasing adaptive capacity, and wherever possible, reduce GHG emissions. Without adaptation, climate change may depress growth in global agriculture yields up to 30 % by 2050 (GCA, 2019).

Agriculture sector is critical for Indian economy contributing to ~ 15 % to gross domestic product (GDP) and employing around 50% of the people either as vocation or as workers. Climate change in the rainfed areas of India could reduce annual agricultural income by up to 20-25 % (India Economic Survey, 2017-18). Rising temperatures and changing monsoon rainfall patterns associated with climate change could shave off 2.8 % of India's GDP and depress the living standards of nearly half its population by 2050 (World Bank, 2018). At the same time, agriculture sector contributes about 19.6% of India's total GHG emissions in 2014 (WRI CAIT 4.0, 2017, FAOSTAT, 2018).

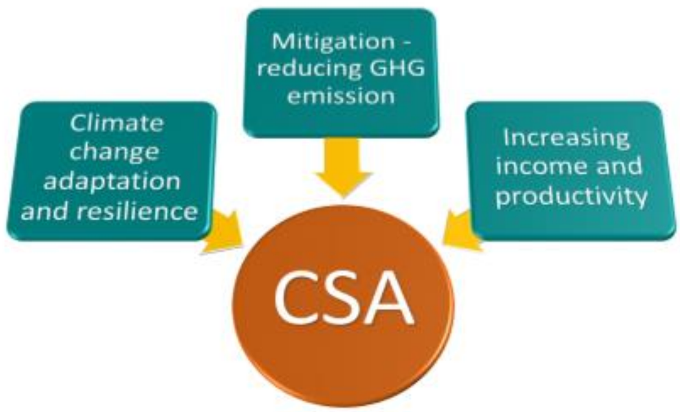

Figure 1. Three pillars of Climate Smart Agriculture (CSA)

Thus, there is an urgent need for building resilience of Indian agriculture to climate change. Climate-smart agriculture is an important approach towards minimizing climate change impacts and a more sustainable food security. CSA provides the framework within which synergies among adaptation, mitigation, and improved food security for small-scale farmers can be identified, developed, and disseminated (Andrieu et al., 2019). The CSA approach pursues the triple objectives of sustainably increasing/ stabilizing productivity and incomes, adapting to climate change and reducing greenhouse gas emissions where possible (FAO, 2012). Climate-smart agriculture (CSA) contributes to a number of sustainable development goals (SDGs) such as poverty reduction, zero hunger, climate action, affordable and clean energy and partnership for the goals.

CSA technologies help cope up with climate change impact on agriculture by achieving goals of adaptation, mitigation and resilience. These technologies vary with location and hence, identification of area specific technologies for resilient farming is a necessity as well as a challenge. Integrated learnings through policy dialogues, stakeholder consultations, training and capacity development have potential to promote local, need based, incremental and transformative adaptation options and for expanding resilient agriculture.

This report outlines the process of developing district level adaptation plan for resilient farming as part of the project "**Strengthening Capacity in India for Scaling-up Climate-Smart Agriculture Technologies, Practices and Services**" by ICAR, CCAFS and CG Centre's. The project aims to contribute towards building a national strategy for scaling out climate resilient agricultural practices and technologies by synthesizing cumulative knowledge, experiences and learnings gained in climate risk management. This is to guide investments being made by the government and donors at the developmental scale in India. The project also aims to strengthen the capacities of stakeholders at the state and national level by providing a knowledge platform generating awareness for potential scaling up opportunities in India.

As part of the project, in the first phase 11 vulnerable districts, one each from 11 Agricultural Technology Application Research Institute (ATARI) zones are identified for developing district climate adaptation plan for resilient agriculture. The report presents district level Climate Adaptation Plan for Resilient Farming for Adilabad district in Telangana state.

2. Methodology and framework

The different steps for developing district climate adaptation plan for resilient farming are given in Figure 2.

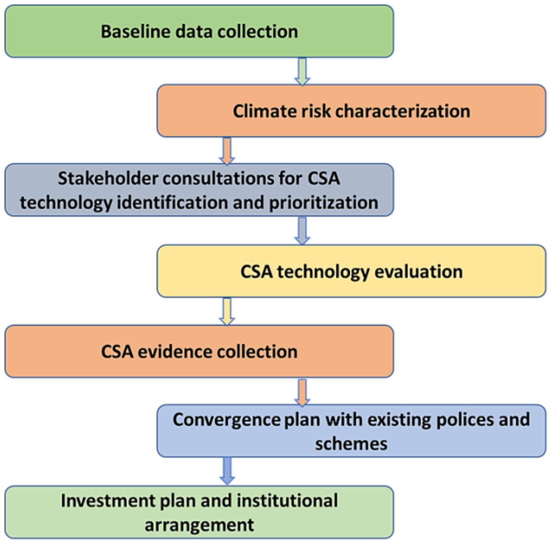

Figure 2. Procedure adopted for the preparation of CSA district level plan

This development of CSA plan involves four main stages, i) climate risk characterization to find out the main risks that occur in a district and their impact on crop production, ii) CSA technology identification, iii) CSA technology prioritization and validation through particpation of and consultation with district stakeholders and iv) developing investment, convergence and institutional framework for scaling up the CSA technologies. Accordingly, the district CSA plan for Adilabad district from Telangana is prepared.

In the first step baseline data collection involves inventory of area specific hydrological, agricultural, soil, livestock, fishery and socio-economic data. This data helps to support the framework at different levels. The climatic risk characterization involves the identification of different risks by analyzing rainfall and temperature data. The identification of risk is necessary to know occurrence of risk and its impact on different production systems *viz.* crop, livestock, fisheries etc. The next step is stakeholders' consultations for CSA technology identification and prioritization. Stakeholder's consultation provides platform to identify area specific CSA technologies and subjecting them to prioritization framework. CSA technology prioritization framework is used for the assessment of technologies based on different levels such as implementation feasibility, incentive mechanisms needed, adoption barriers and key institutions for the selection of top performing technologies. CSA evidence collection process involves the collection of evidences on performance or effectiveness of selected best technologies/practices with respect to various aspects of CSA. Also gap in research for finding evidences of technologies can be known at this stage. Information of existing government schemes and policies is needed for planning convergence of resources from various schemes/programs. Developing a convergence plan for a more cohesive and purposeful implementation of existing policies and schemes involves identification of opportunities for linkage of selected technologies with existing government schemes and wherever possible to make arrangements of investments needed for the implementation of CSA plan. Investment plan and institutional arrangements involve specifying the detailed year-wise implementation plan with phasing of budget for uniform and equitable development. The institutional arrangement involves the information of program implementation committee for smooth operation and monitoring activities at different levels of operation. The total process involves three phase operation with pre-implementation, implementation and post implementation activities for successful operation and outcomes.

3. Adilabad at a glance

3.1 District Profile

Adilabad is one of the 33 districts of Telangana state and is located in the northern region of Telangana state (Figure 3). Geographical area of the district is 3982 km^2 (~ 3.7 % of total state area). Adilabad comprises of 18 (17 Rural + 1 Urban) number of Blocks/Revenues Mandal's. As per census 2011, population of district was 708972 (2.1% of total state population) with 50.3% of male and 49.7% of female (Census, 2011). Rural population comprised 76.4% of the total population with urban population at 23.6%.

3.2 Climate

Climate in Adilabad district is tropical, hot summer and dry except during south-west monsoon season. Maximum temperature ranges between 42 to 28 ^{0}C during summer season and drops to 29 to 15 ^{0}C during winter season. Average rainfall for different blocks of Adilabad district varies from 1089 mm to 1204 mm and annual rainy days varies between 60-67 days. July is the rainiest month with an average of 15-16 rainy days.

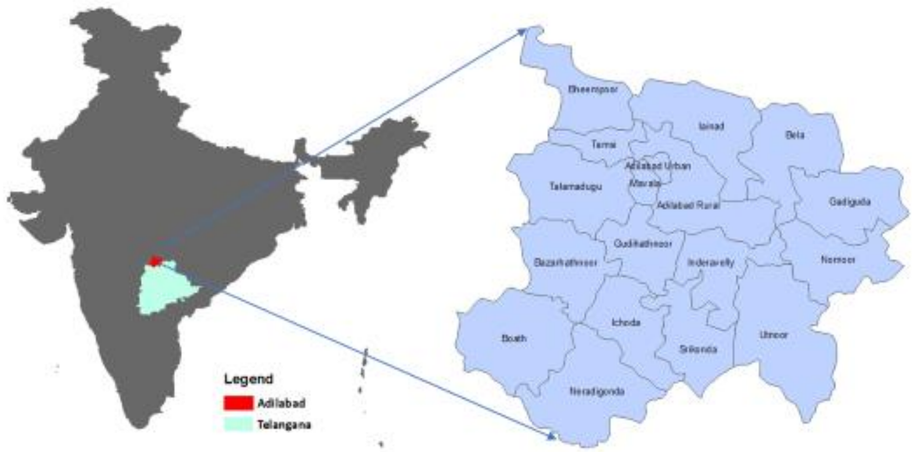

Figure 3. Geographical location of Adilabad district

3.3 Land use

Land utilization particulars in different categories for the year 2016-17 are given at Table 1.

Table 1. Land Utilization Particulars of Adilabad District 2016-17

Particulars	Area (Ha)
1. Forests	172472
2. Area Under Non Agricultural Uses	6438
3. Barren and Un-culturable Land	8583
4. Permanent Pasture and Other Grazing Land	4386
5. Land Under Misc. Tree Crops and Groves not Included in Net Area Sown	175
6. Culturable Waste Land	3796
7. Fallow land	920
8. Net Area Sown	200361
Total area reporting for LUS	**397131**

(Source: DAC net, Govt. of India, 2016-17)

The net sown area (NSA) and forests cover contribute maximum of Adilabad area which makes up about 50% and 43 % respectively. The area not suitable for cultivations is 4% while the permanent pasture, culturable waste and fallow land includes 3% of the total district area.

3.4 Cropping pattern

There are three cropping seasons: *kharif*, *rabi* and summer. *Kharif* season starts in mid of June and lasts till end of September, *rabi* season starts in mid-October and ends in mid of January while summer season starts early in third week of January and ends in mid of April. In *Kharif* season, cotton is the major crop and occupies maximum share of around 65% among all crops sown in the district. The average total area under Cotton was 1,13,904 ha during the year 2016 to 2019 (Appendix 5). The cotton crop is followed by soybean, red gram and Jowar in *kharif* season. Black gram and Green gram are also grown on 2-3% cultivable area during *Kharif* season. Among *kharif* season crops, cotton and redgram are continued till December/January.

The *Rabi* cultivation is limited to 10% of the *kharif* cultivation only as rainfed cultivation is predominant in the district. Bengal gram covers 70% of area cultivated during *Rabi* season. Jowar, wheat, ground nut, sesame etc. are other crops grown in *Rabi* season. The vegetable crops include coriander, onion, lady finger, brinjal, tomatoes, green chilies, turmeric etc. with 2-3% of total cultivable area grown in *kharif* and *rabi* season.

The crop area distribution and cropping intensity information for all the blocks in the year 2014-15 is given in Table 2. The total gross sown area was 199.85 (‘000 ha) and net sown area was 199.02 (‘000 ha).

Table 2. Crop area distribution (in ‘000 ha) and cropping intensity in different blocks of Adilabad (Year 2014-15)

Sr.No	Block/Taluq/Mandal	GSA	NSA	GIA	NIA	CI (%)
1	Tamsi	18.96	18.88	0.98	0.98	100.4
2	Adilabad (Rural, Urban & Mavala)	15.76	15.73	0.45	0.41	100.2
3	Jainad	20.73	20.69	0.4	0.38	100.2
4	Bela	16.1	16.07	0.91	0.91	100.2
5	Talamaduga	14.88	14.81	0.51	0.44	100.5
6	Gudihathnoor	11.08	10.98	1.59	1.49	100.9
7	Ichoda & Sirikonda	15.31	15.23	1.23	1.23	100.5
8	Bazarhathnoor	11.98	11.92	0.6	0.6	100.5
9	Boath	15.25	15.03	1.8	1.8	100.5
10	Neradigonda	9.37	9.25	1.22	1.22	100.3
11	Indervelly	18.02	18.02	0.23	0.23	100.0
12	Narnoor, Gadiguda & Bheemapur	17.58	17.58	0.36	0.36	100.0
13	Utnoor	14.83	14.83	0.81	0.81	100.0
	Total	**199.85**	**199.02**	**11.09**	**10.86**	

NSA: Net Sown Area; GSA: Gross Sown Area; NIA: Net Irrigated Area; GIA: Gross Irrigated Area; CI: Cropping Intensity

(Source: Hand book of Statistics, Compiled and published by Chief Planning Officer, Adilabad)

Cropping intensity is found more than 100% in all blocks. Net sown area contributes 50% of the total geographical area of district in which Jainad block is having maximum net sown area than other blocks and contributes to 10% of total net sown area.

3.5 Farm holdings

Figure 4 presents the percentage of farm holdings under different categories. Small (1-2 ha) and semi-medium farmers (2-4 ha) are predominant category contributing 35% and 37% of farm holding, respectively. Large farm holders are only 1.46%. The smallholder farms are more vulnerable to climatic as well as non-climatic stresses.

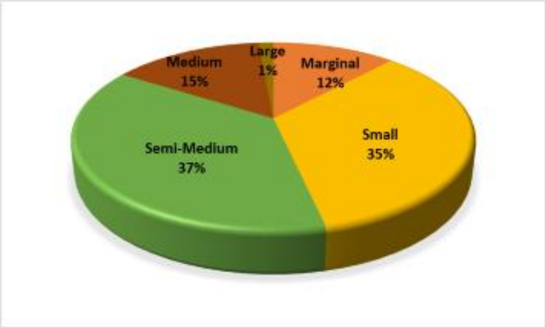

Figure 4. Farm holding details of Adilabad district

3.6 Irrigation

Overall, Adilabad district has 75% of total cultivated area as rainfed and 25% area irrigated. Gross irrigated area in 2016-17 was 22,580 ha and out of this 2% area is irrigated by canal and tanks while 95% area is irrigated by groundwater through wells and remaining 3% is irrigated by other sources. Figure 5 presents the percentage of irrigation for each taluka of Adilabad district. Gudighathnoor, Ichoda, Narnoor and Bheeempoor are mostly rainfed blocks as shown in Figure 5, while Inderavely, Talamadugu, Adilabad urban has maximum area under irrigation.

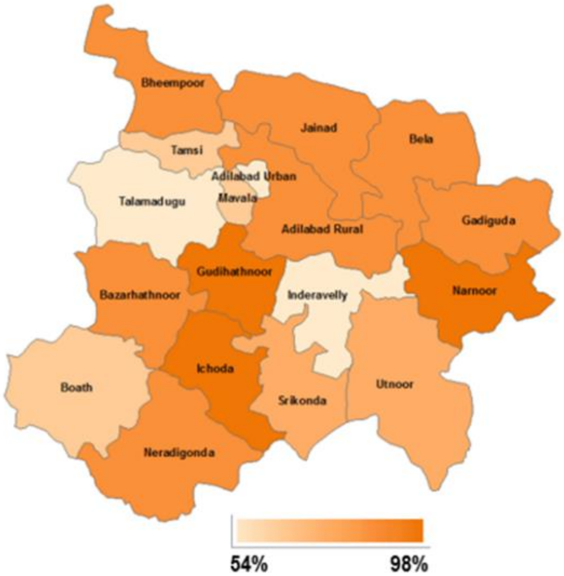

Figure 5. Area distribution of different blocks under rainfed systems

3.7 Water availability

In Adilabad district, the water availability through rainfall is 788 MCM. The storage capacity in existing surface water bodies is 173 MCM and ground water availabilty of 296 MCM which comprises total water availability to 469MCM (DIP reoprt of Adilabad, 2016). There are different irrigation sources under district such as minor tanks-458, farm ponds-14422, open wells-4052, and tubewells-6843. About 458 minor irrigation tanks distributed across the district contribute to about 32,561 ha area under irrigation. Block wise area covered by minor irrigation tanks is shown in Figure 6. The district receives about 20,915 ha-m groundwater recharge in monsoon season from rainfall and other water sources while in non-monsoon season it receives 8003 ha-m of recharge. Overall 63% of groundwater is extracted from all the blocks of district. Ichoda, Gudihathnur, Tamsi, Mavala, boath and Neradigoda are the blocks extracting more groundwater than total recharge.

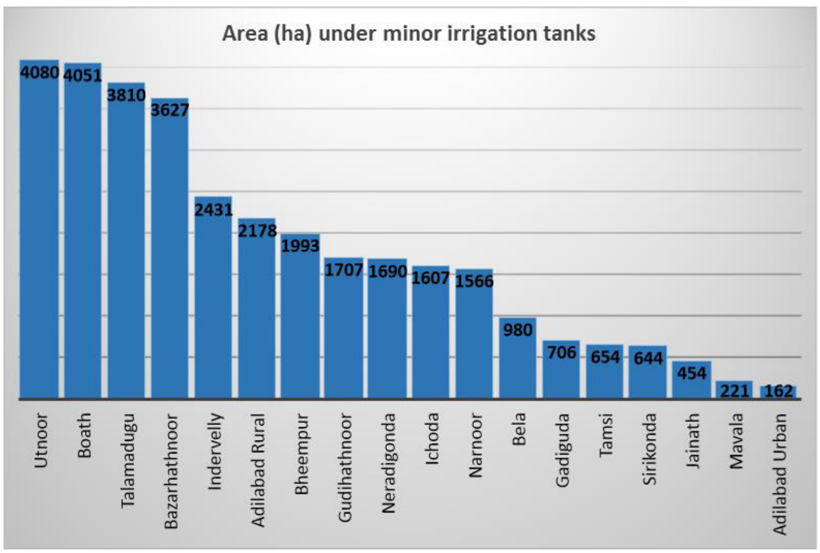

Figure 6. Area under minor irrigation tanks

3.8 Soil

Soil of Adilabad district is mostly includes black and red soil type. Block wise different soil types are given in Figure 7. Most of the area comes under clayey soil type followed by gravelly clay, loamy, cracking clay and calcareous clay. Soil depth in Adilabad district varies from shallow and deep black soil as shown in Figure 8. Major area falls under shallow soil followed by very shallow, moderately deep, deep and moderate shallow.

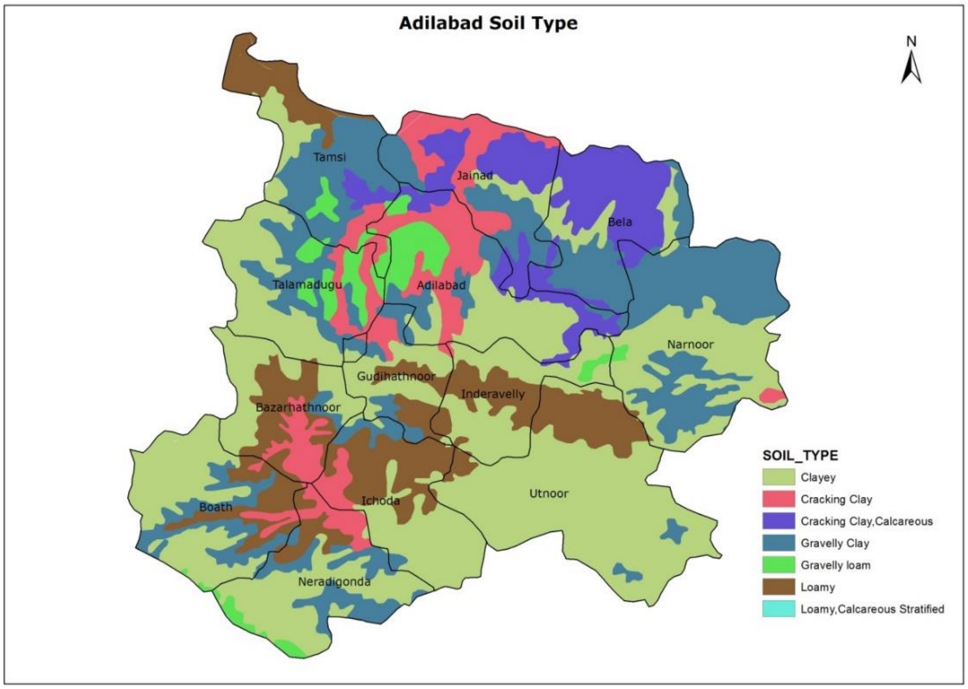

Figure 7. Soil type in Adilabad district

(Source: Extracted from Soil Resource Maps of Andhra Pradesh, NBSSLUP)

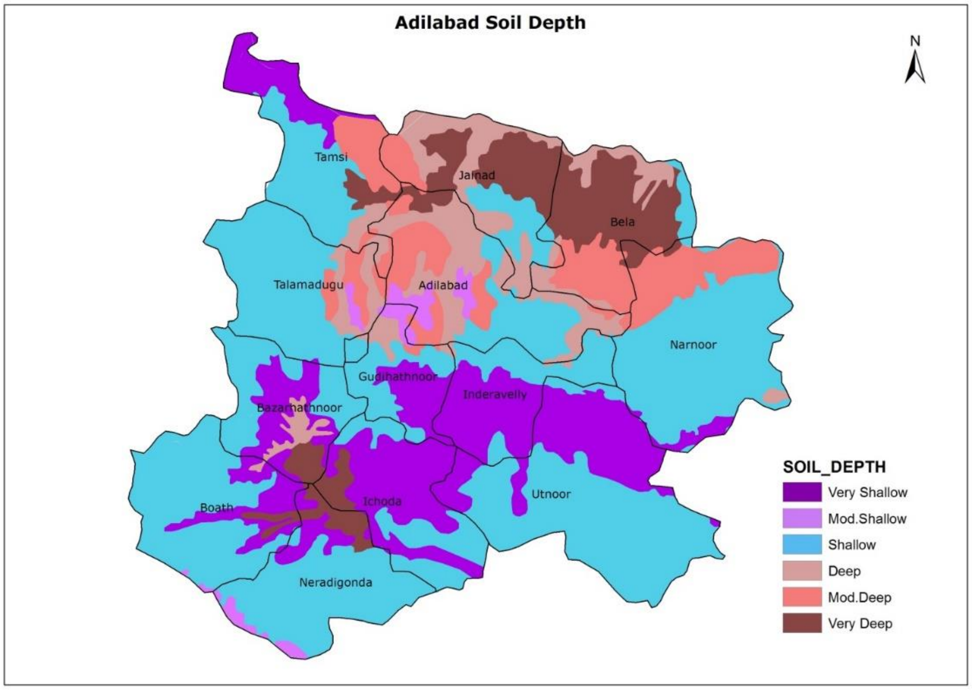

Figure 8. Soil depth in Adilabad district

(Source: Extracted from Soil Resource Maps of Andhra Pradesh, NBSSLUP)

3.9 Livestock and poultry

Large share of crop production in Adilabad district system is depend on rainfed system. Integrated activities like livestock and poultry production help to sustain the rainfed ecosystem. Livestock and poultry can be assured source of income to the small farm holders. Cattle, buffalo, sheep, goat and fowl are main livestock classes present in the Adilabad district. The total districts milk and meat production was 21800 million tones (MTs) and 1330 MTs respectively, in year 2019. Poultry is another secondary income resource to the farmers. In district, around 64 lakhs egg's production was produced from approximately 5 lakh poultry in year 2019.

3.10 Agriculture research issues, challenges and knowledge gaps in the district

The district faces challenges in adoption of improved technologies for farming, livestock and other systems. Some issues related to agriculture and knowledge gaps identified by researcher groups from Krishi Vigyan Kendra, Adilabad are given below:

- Un-even rainfall distribution and variability in monsoon causing changes in the cropping pattern
- Replacement of nutritious crops cultivation (sorghum) by cotton and soybean over a period of time
- Lack of awareness on modern agricultural production practices and new varieties
- Lack of knowledge on pest and disease management and indiscriminate use of more pesticides and weedicides
- Low adoption of water conservation and management practices
- Low adoption of farm mechanization
- Burning of crop residues (cotton crop residues) and no recycling of crop residues for vermi-compost preparation
- Indiscriminate use of fertilizers and poor soil health management
- Cultivating local varieties (Redgram) years together, mono cropping of cotton (bt hybrids)
- Lack of cold storages facilities for long term storage of vegetables
- Lack of awareness about the subsidiary income generation activities like backyard poultry, dairy and goat farming through Integrated Farming Systems
- Non-adoption of integrated farming systems
- Lack of awareness on suitable alternative crops for *rabi* season
- Insufficient water availability for cultivation of crops post-harvest of cotton and pigeonpea
- Little awareness on cost reduction technologies in various crops
- Lack of Drudgery reducing technologies for farm women
- Non availability of income generation activities for the farm women
- Low level of industrial infrastructure for Agro processing and value addition

4. Climate Risk characterization

Climate risk assessment is important in agricultural planning to mitigate the impacts of climate variability and extreme events. Different climate and weather systems affect different farming decisions and hence climate risk characterization is essential in planning and reducing the risks associated with climate anomalies. The climate risk characterization was done for identifying major risk hazards in the Adilabad district. In addition to climate risk characterization using climate data, stakeholders' consultation was also done to identify the main climatic risks to major cropping systems (Appendix-1).

4.1 Rainfall

In Adilabad, about 85% of rainfall is received during south west monsoon season. Long term India Meteorological Department (IMD) rainfall data of 0.25°x0.25° for the duration of 1981 to 2015 was used to identify extreme rainfall, dry spell and rainfall deficits. The average annual rainfall of the district is 1146 mm. Average rainfall is high in Gadihathnur, Narnoor, Inderavelly, Ichoda and Srikonda, moderate in Adilabad urban and rural, Mavala, Neradiguda, Gadiguda, Boath, Bazarhathnoor, Talamdugu and less in Bheempur, Tamsi, Jainad and Bela (Figure 9).

Figure 9. Average annual rainfall for different blocks of Adilabad

July is the peak rainy month and receives average 300mm of rainfall. The average annual number of rainy days for June, July, August and September are 11, 16, 15 and 10 respectively. October receives comparatively less rainfall of 76 mm with average 4 number of rainy days. The monthly average rainfall over the period from 1981 to 2015 is shown in Figure 10 and it depicts maximum rainfall contribution from July and August is in the range of 300 to 340mm followed by June and September.

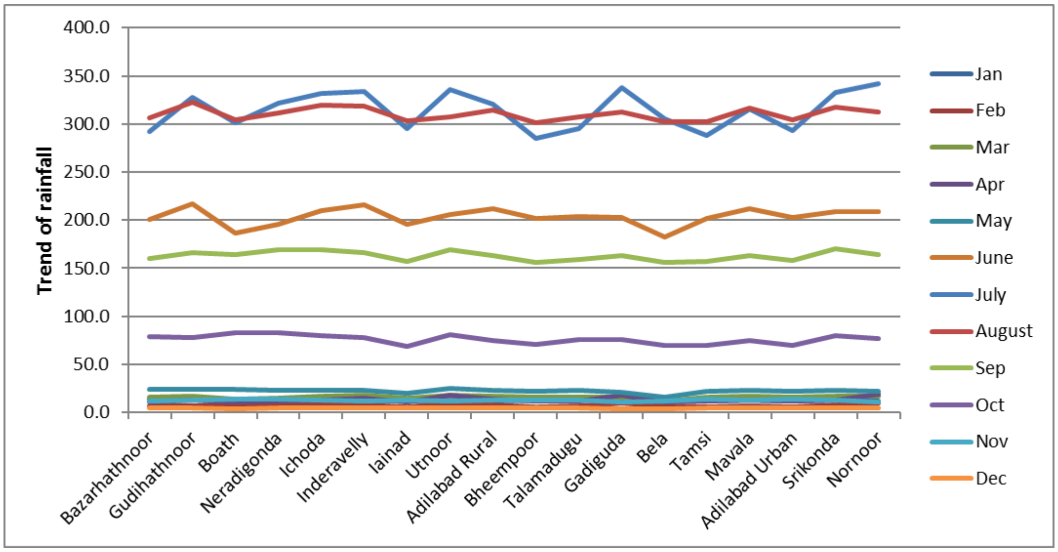

Figure 10. Average monthly rainfall for all blocks in Adilabad

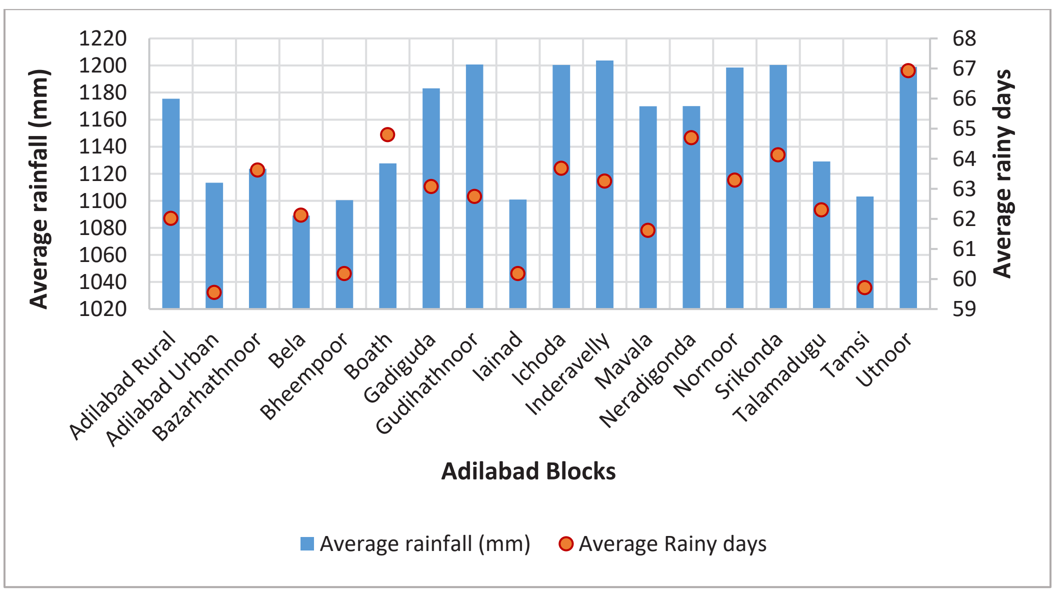

Figure 11. Block wise average annual rainfall and rainy days for the period of 1981-2015

The average annual number of rainy days' ranges in 60-67 days and rainfall ranges in 1100 - 1200mm for all blocks in Adilabad district as shown in Figure 11. High amount of rainfall during July and august month offers scope for water harvesting and same could be utilized for supplemental irrigation during October to December months for cotton and redgram crops.

4.1.1 Trend of Rainfall

The long term average annual rainfall during the period of year 1981 to 2015 for Adilabad district is shown in Figure 12. The trend line of average annual rainfall shows decreasing trend in annual rainfall. The coefficient of variation was obtained 0.3, which shows lower variability from the mean.

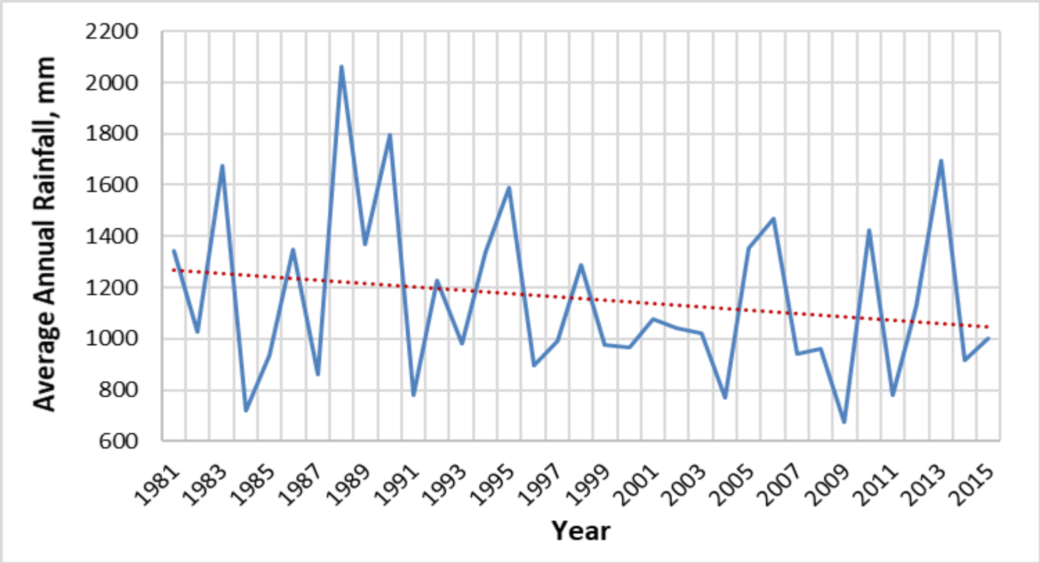

Figure 12. Trend of average annual rainfall in Adilabad

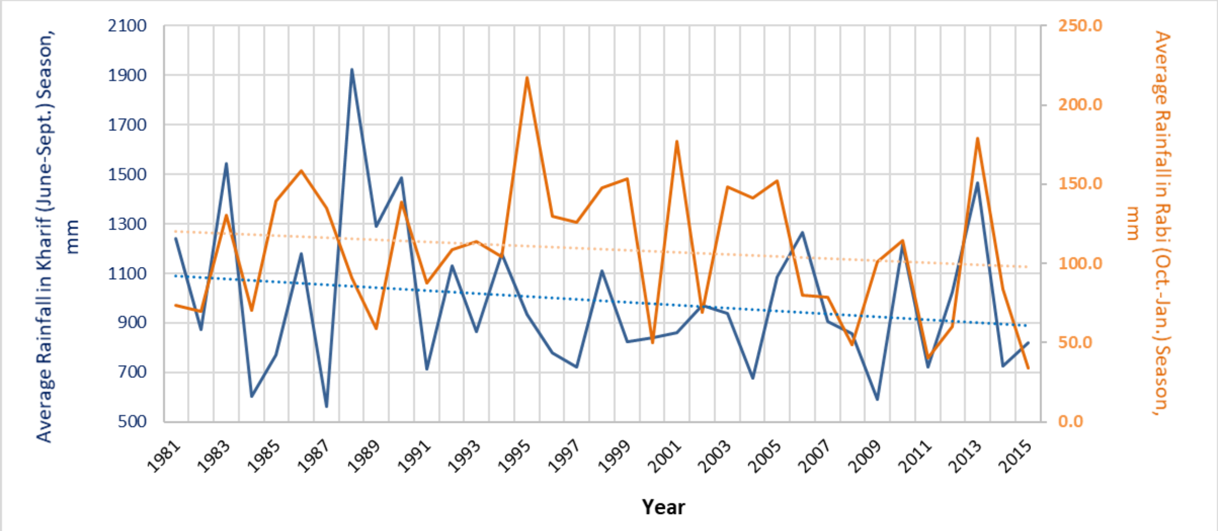

Figure 13. Trend of average rainfall during kharif and rabi season in Adilabad

Long term (1981-2015) seasonal rainfall analysis is carried out and presented in Figure 13. The total average rainfall received during *Kharif* and *Rabi* season in Adilabad district is 991mm and 109mm, respectively. The trend of seasonal rainfall is seen decreasing from 1981 to 2015. In the decade of year 1981 to 1990, the average rainfall received was found more the in next 2 decades.

The unseasonal rainfall in *Rabi* season, damages the long duration *Kharif* crops during harvest time.

4.1.2 Rainy days

The average annual number of rainy days for the district from year 1981 to 2015 are shown in Figure 14. The long term trend line shows decrease in average annual rainy days. The coefficient of variation is found less than 0.2, suggesting lower variability from the mean.

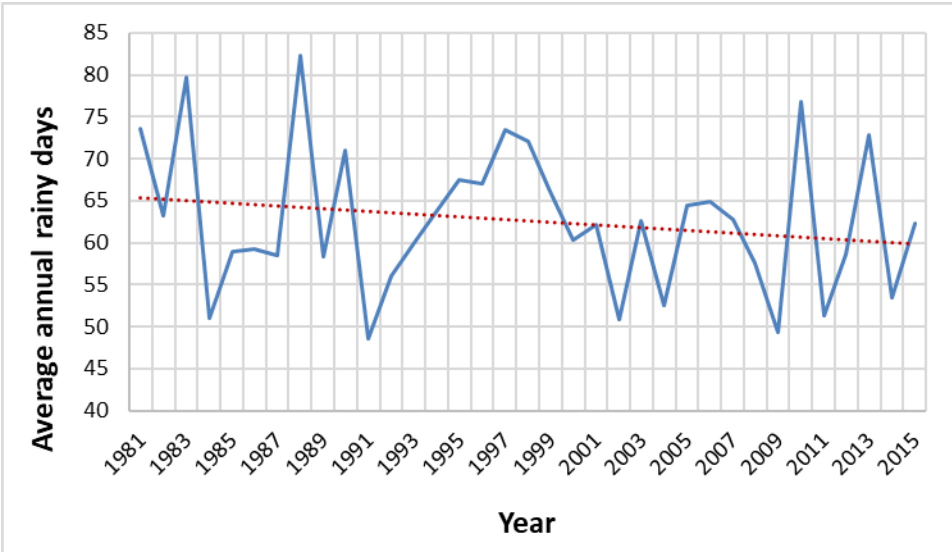

Figure 14. Trend of average annual rainy days

4.1.3 Excess and deficit rainfall

Excess rainfall leads to water logging, flood, landslides, soil erosion, risk to human life, infrastructure, loss of crop and livestock production. However, deficit rainfall raises drought concerns which may lead to water deficiency and failure of crops. The rainfall is classified as excess, normal, deficient or scanty as per the following criteria proposed by IMD. Excess: +20% of normal or more, Normal: + 19% to -19% of normal, Deficient -20% to -59% of normal, and Scanty: -60 % of normal or less. The analysis was carried out for long term rainfall (1981 to 2015) for different periods: annual, monthly from June to December, *Kharif* season and *Rabi* season, and June- December periods. Figure 15 shows the percent of years (for the duration 1981-2015) which witnessed rainfall extremes. Gadiguda, Nornoor, Adilabad Rural, Inderavelly, Gadihathnoor etc. has more frequency of excess rainfall events. Bela, Jainad, Adilabad rural, Inderavelly, Tamsi and Gadiguda are the blocks having about 32-81% of area vulnerable to excess rainfall conditions, also 8.2% of the total geographical area is flood prone (Amarnath et. al., 2017).

However, the frequency of rainfall deficits is higher (60-80%) in the month of November, December and *Rabi* season during the period of 1981-2015 as shown in Figure 16. Tamsi, Adilabad rural, Bheempur, Boath and Utnoor has showed more number of rainfall deficit years.

Rabi season is most vulnerable with 30-40% of years witnessing rainfall excess and 60-70% deficit years.

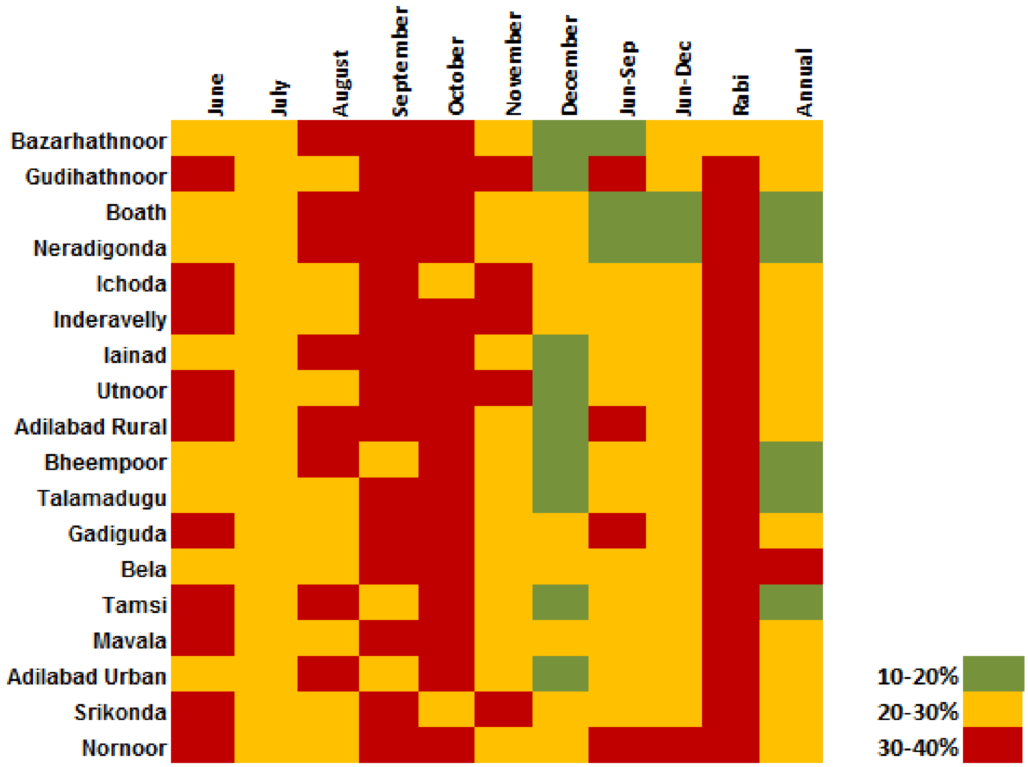

Figure 15. Frequency of excess rainfall

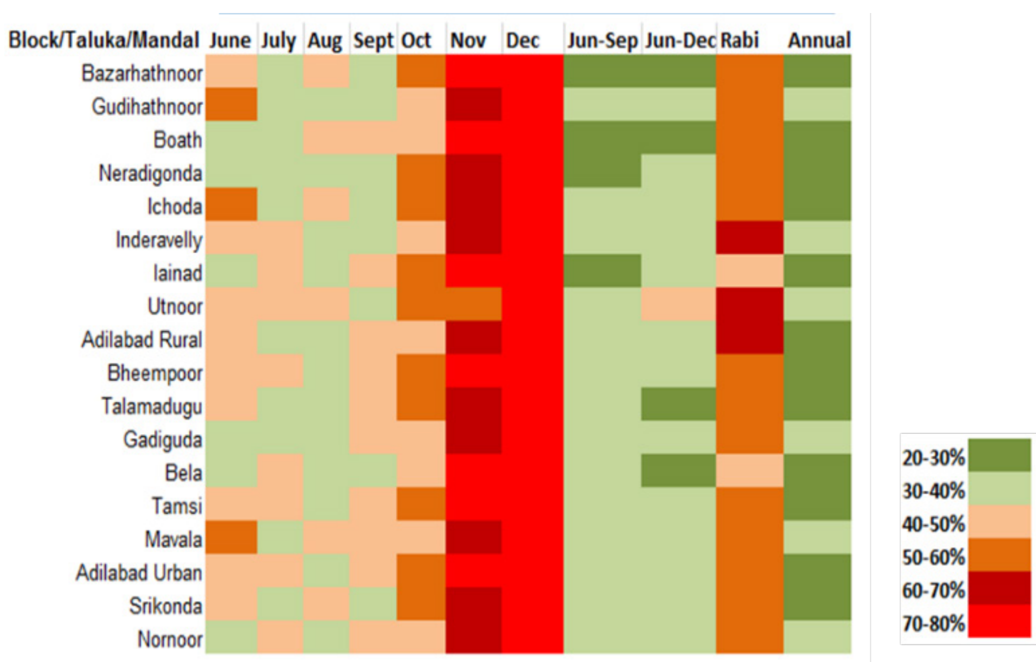

Figure 16. Frequency of rainfall deficit

4.2 Dry spell

Agriculture in Adilabad district is highly dependent on monsoon rainfall and exposed to dry spells and drought conditions as majority of agriculture is rainfed. Prolonged period of dry spell has adverse effect on *kharif* crops like cotton, soybean which are largely rainfed. Dry spell is a sequence of dry days including days with less than a threshold value of rainfall. It leads to moisture deficit and prolonged dry spell in the rainy season leads to drought. Dry spells analysis was carried out using IMD gridded rainfall data for JAS: July to September, JJAS: June to September and JJASO: June to October for all blocks of Adilabad and presented graphically in Figure 17.

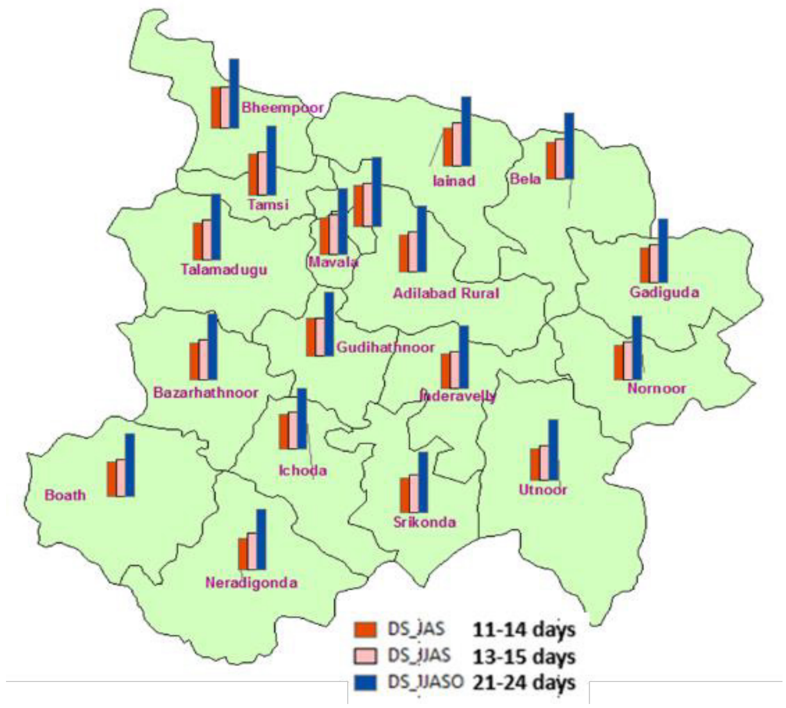

Figure 17. Dry spell length for different blocks of Adilabad

The average duration of dry spell obtained in JAS, JJAS and JJASO seasons are 11-14 day, 13-15 days and 21-24 days, respectively. Since large area is under cotton and redgram which are in the field till December, lack of sufficient rain during October to December leads to moisture stress.

4.3 Temperature

Temperature in Adilabad district varies through all the seasons in a year. The cold weather commences towards the end of November when the temperature begins to fall rapidly. December is generally the coldest month, with the mean daily maximum temperature of about 29^{o}C and the mean daily minimum of 15^{o}C. Cold wave may occur during this period which affects *rabi* cropping system. Cotton crop is sensitive to cold temperature. Cold temperature has effect on cotton seed germination which may lead to crop damage due to root abortion. Also, redgram crop is sensitive to low temperature condition which have impact on yield. The period from

March to May is the hottest month with the mean daily maximum temperature of about 42°C and a mean daily minimum of about 28°C. The days are intensely very hot and on individual days the temperature may go up to 46°C. Heat wave is the problem during this period. With the advance of south-west monsoon by middle of June there is an appreciable drop in temperatures. At the 1st week of October when the monsoon withdraws, the day temperature begins to increase slightly but the night temperatures steadily decreases. After November both day and night temperatures decrease rapidly.

The relative humidity is high generally during the south-west monsoon season. The air is generally dry during the rest of the year.

4.4 Waterlogging

As per the evidences, some of the Adilabad blocks such as Bazarhathnoor, Bela, Boath, Echoda and Jainath are prone to the waterlogging condition. This waterlogging condition is mainly caused by black soil which contains heavy clay material and holds more moisture in the root zone. Excess rainfall condition in September, October and even in *rabi* season causes water logging in early stage of *rabi* crops. This leads to crop damage or failure in early stages and affects productivity.

4.5 Stakeholders' risks perception

During the stakeholders' workshop ranking of climatic risks in the district on 0-5 scale was also taken, where 0 indicates no risk, 1- very low risk, 2- low risk, 3- medium risk, 4-high risk and 5- very high risk. The ranking of climatic risks as perceived by stakeholders is shown in Figure 18.

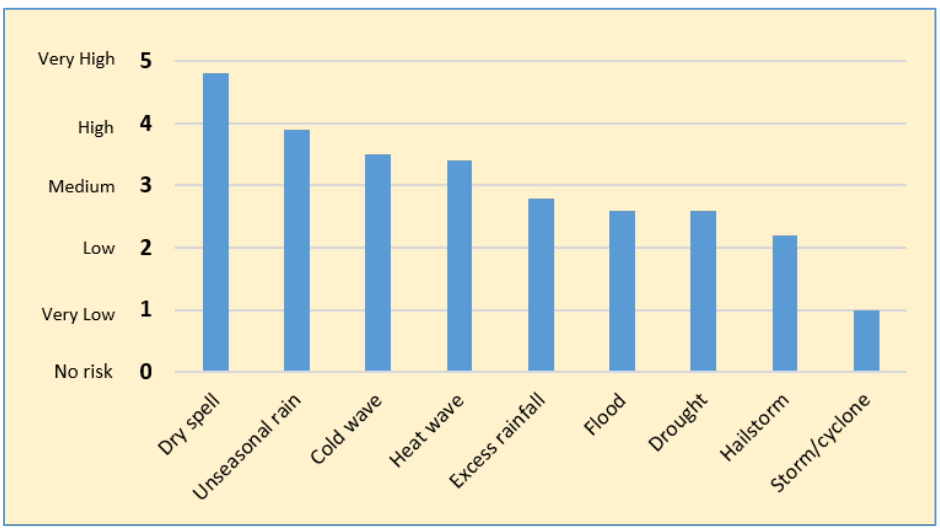

Figure 18. Climatic risks ranking frequency marked by stakeholders

Stakeholders identified the risk as per their experiences and evidences in Adilabad district. Risk from dry spell ranks higher followed by unseasonal rains which depicts *Kharif* season as most vulnerable and hence *Kharif* cropping system needs more attention in the form of climate resilient measures. Cold wave and heat wave have an equal importance while excess rainfall, flood and drought have also same level of occurrence as per the stakeholder's opinion. Since dry spells and drought are interlinked, from farmers' perception, it appears though dry spells are common, impact of the same leading to drought is less and reduction in crop yield might also be less. Major climatic risk of long dry spell as identified in the above risk analysis in JJASO throughout the *kharif* season is validated here with stakeholders' observation. Similarly, their perception and experience also supports our analysis suggesting importance of excess rainfall and drought as the key climatic risks.

The summary of block wise soil type, cropping system, dry spell period, extreme rainfall and drought hazardous area and climate risk is given in Table 3.

Table: 3 Block wise soil, cropping system and climate risks in Adilabad district

Sr. No.	Block/ tehsil/ mandal	Soil type and depth	Crop name	Dry spell duration (days)[1]			Extreme rainfall hazard area[2] (km^2)	Drought hazard area[3] (km^2)	Vulnerability to
				JAS	JJAS	JJASO			
1	Adilabad (Rural)	Deep and shallow black soils, red clay soils and rock lands	Cotton, Red gram, Soybean, Jowar	13	14	23	142.75	203	Dry spells Hail storms Heat wave
2	Adilabad (Urban)	Red gravely loamy soils and shallow black soils	Cotton, Red gram, Soybean, Jowar	14	15	24	1.25	7.5	Dry spells Hail storms Heat wave
3	Bazarhathnoor	Deep calcareous black soils, deep black soils and shallow black soils	Cotton, Soybean, Red gram	13	14	23	0	180	Dry spells, water logging heat wave
4	Bela	Deep calcareous black soils,red clay soils and rock lands	Cotton, Soybean, Red gram, Bengal gram	13	14	23	211	208	Dry spells, Temporary water logging Heat wave
5	Bheempur	Shallow black soils and Rock lands	Cotton, Soybean, Red gram, Bengal gram	14	14	24	33.25	146.75	Dry spells Heat wave

[1] Average dry spell duration estimated using long term analysis for the period of 1981-2015, JAS-July to September, JJAS-June to September and JJASO- June to October.

[2] Extreme rainfall hazard area identified using APHRODITE and TRMM data for 1951-2013, Amarnath et.al, 2017.

[3] Drought hazard area identified from Normalized Difference Drought Index (NDDI) using MODIS surface reflectance 13 years (2001-2013) timeseries

6	Boath	Shallow black soils, deep black soils and Deep calcareous black soils,	Cotton, Soybean, Red gram, Jowar	12	13	22	0	181	Dry spells Water logging Heat wave
7	Echoda	Shallow black soils and rock land soils	Cotton, Soybean, Red gram	12	13	22	76	185.75	Dry spells Water logging Cold injury
8	Gadiguda	Deep and shallow black soils	Cotton, Soybean, Red gram, Jowar	13	13	22	2.25	132.5	Dry spells
9	Gudihatnoor	Shallow black soils	Cotton, Soybean, Red gram	13	15	24	173.75	252	Dry spells Hail storms Heat wave
10	Indervally	Shallow black soils	Cotton, Soybean, Red gram, Jowar	12	13	21	0	180.5	Dry spells Heat wave
11	Jainath	Deep black soils, shallow black soils, red clay soils and Red shallow gravely clay soils	Cotton, Soybean	12	13	22	78.75	183.25	Dry spells Water logging Floods Cold injury heat wave
12	Mavala	Red gravely loamy soils and deep calcareous black soils	Cotton, Soybean	13	14	23	3.25	17.75	Dry spells Heat wave
13	Narnoor	Shallow black soils	Cotton, Soybean, Red gram, Jowar	11	13	21	0	204.5	Dry spells Heat wave
14	Neradigonda	Shallow and Deep black soils	Cotton, Soybean, Red gram	12	13	22	38.75	185.75	Dry spells Heat wave
15	Sirikonda	Shallow black soils	Cotton, Soybean, Red gram	12	13	21	8.75	142	Dry spells Heat wave
16	Talamadugu	Shallow and Deep black soils, Red gravely loam soils	Cotton, Soybean, Red gram, Bengal gram	13	14	23	42.5	185.5	Dry spells Heat wave
17	Tamsi	Shallow and Deep black soils	Cotton, Soybean, Red gram, Bengal gram	14	15	24	32.25	78.25	Dry spells Hail storms Heat wave

18	Utnoor	Shallow black soils	Cotton, Soybean, Red gram	11	12	21	74.5	265.75	Dry spells Heat wave

4.6 Summary of risks

Changes in rainfall and temperature pattern pose serious risks to farm production system. Climate risk analysis shows that rainfall deficit, dry spells and extreme rainfall events are common in Adilabad district. Stakeholders also prioritized dry spells and unseasonal rainfall as the potential climate risks in Adilabad district (Appendix 1). Based on the risks identified, summary of impact of climate risks on different cropping system across different crop growing season is summarized in Table 4.

Table 4. Summary of impact of different climate risks on cropping system in different seasons

Season	Soil types	Cropping system	Climate risks	Impact of climate risk on cropping system
Kharif	Black soil	Cotton – Fallow Cotton + Redgram (8:1) Soybean + Redgram (6:1) Jowar – fallow Tomato- fallow	Dry spell, Excess and uneven rainfall	• Low yields due cultivation under rainfed situation • Crop damage due to rainfall at harvest time (cotton) • Low yields to moisture stress at reproductive stage • Vulnerability due to dry spells and drought • Reduction in quality of produce and low market price
	Red soil	Cotton – Fallow Cotton + Redgram (8:1) Soybean + Redgram (6:1) Jowar-Fallow		
Rabi	Black soil	Cotton – Sesamum /Maize Cotton + Redgram (8:1) Soybean – Bengalgram/ Coriander/mustard Soybean - Maize/Jowar/Wheat Soybean - Vegetables Turmeric/ginger Turmeric + maize-sesamum Tomato-leafy Vegetables/ Cabbage/ Cauliflower Vegetables - Vegetables	Drought	• Crop loss due to water logging with excess rains at early stages (possibility is only 20-30% as mentioned earlier) • Flower drop due to water stress, rains • Low yields in long duration varieties due to moisture stress at reproductive stage • Low returns
	Red soil	Cotton - Fallow Cotton – Ground nut Cotton + Redgram (8:1) Paddy - fallow		

Hot weather			Heat wave	• Lack of water supply and moisture stress • Heat wave damage to crops • Crop failure

4.6.1 Impact of climate risk on livestock and poultry

Changes in temperature due to climate variability is the most critical factor for livestock and poultry production system. Heat stress resulted from increase in temperature, may increases daily water consumption, reduces feed intake which decreases milk production, reproduction and meat production in livestock system. In poultry, increased temperature reduces reproduction rate in hens and consequently lower the egg and chicken production. Long dry season and uneven rainfall reduces the forage quality and growth, and low forage availability affect the production, body weight and decreased resistance to disease. Hence, there is urgent need of focus on livestock system along with cropping system.

5. CSA technology identification and prioritization

Many agricultural practices and technologies could enhance resilience and improve crop yields, water and nutrient use efficiency and also have co-benefit of reducing Greenhouse Gas (GHG) emissions from agricultural activities *(Branca et al., 2011; Jat et al., 2014; Sapkota et al., 2015)*. Though, there are many suitable CSA technologies, it is necessary to identify and invest in those technologies/practices that are situation specific and cost effective. The need is to select locally appropriate CSA technologies, products, and practices that help address the impacts of the changing environmental conditions, and will suit the developing economic trajectories in India. Basically, the identification and prioritization of CSA technologies and practices support climate change adaptation planning in agriculture by designing and implementing situation specific portfolio of smart practices across the given socio-economic and agro-environmental conditions. For the identification of best technologies/practices, it is required to evaluate them for different parameters, such as their impact on production and income, feasibility in implementation, adoption barriers, availability of finance, inputs, markets, government support, subsidies etc. Field consultation with wide range of stakeholders including farmers, researchers, agricultural officers and field implementers is required for prioritization and selection of area and crop specific best CSA technologies.

5.1 Stakeholders consultation for CSA technology prioritization

Stakeholders' consultation workshops were organized to identify and evaluate a range of climate smart agricultural technologies, practices and services in Adilabad district. The list of participants included officers from the district agriculture departments, extension offices, agriculture research institutions, development organizations and private sector (NGO) along with farmers and local resource persons. Stakeholders from government, development and private sector were selected based on their area of work, knowledge on climate change adaptation in agriculture, and working experience with farming communities in the district.

5.2 CSA technology prioritization

A list of CSA technologies under different categories of water-smart, energy-smart, carbon-smart, nutrient -smart, weather-smart and knowledge-smart interventions was shared with stakeholders as a suggestive list to select and prioritize technologies and they were asked to list any other appropriate technology that is not included but relevant to their area (Appendix-2). The steps used for CSA technology prioritization are shown in Figure 19.

Potential CSA technologies for 18 blocks of Adilabad district were identified by stakeholders. Identified list of technology was then evaluated for different parameters to know the implementation feasibility, acceptability, adoption barriers, synergy with government plans/schemes, incentive mechanisms and key institutions required. The stakeholders' prioritization of CSA technologies provides valuable information for planning and designing CSA interventions and resultant investment planning in developing adaptation plan and mitigation options for resilient agriculture.

Figure 19. Step wise procedure used in stakeholder's workshop for CSA technology prioritization

In each step of CSA technology prioritization, stakeholders were asked for the area specific information on indicators relevant to CSA technologies. The details are given in Table 5.

Table 5. Indicators used for the different stages of CSA technology prioritization

Stages	Indicators
1. List of possible interventions in block	Existing and possible major CSA intervention in districts under water, nutrient, energy, carbon, weather and knowledge smart categories
2. CSA Interventions feasibility to climate risk	List of major climatic risk in district and feasibility of CSA interventions to major climatic risk in district
3. Evaluation of CSA interventions	Prioritization of CSA interventions on the basis of cropping system, type of crops, type of vulnerable risk, change in production and income, change in resource use i.e. mitigation and reduction in climate risk i.e. resilience.
4. Implementation feasibility of CSA	Implementation feasibility of CSA interventions in terms of cost of technology, gender inclusivity, technical feasibility, and synergy with government plans.
5. Assessment of adoption level and barriers	Availability of finance, inputs, awareness of technology, awareness and acceptability of technology, government support for adoption of technology, different extension services

6. Incentive mechanisms to promote CSA interventions	Available subsidy for CSA technology, access to affordable farm credit, capacity building and access to market
7. Key institutions to scale out CSA	Role/support of different institution for scaling out CSA intervention. Private sector retailers, Non-Government Organizations, Farmer Producer Organizations, Custom Hiring Centers, Women Self Help Groups, Youth Farmer Centers

Stakeholder's inputs in CSA prioritization were used for analyzing and selecting the best practices. For this, CSA smartness scores (CSA-SS) index was used for the evaluation of CSA interventions. CSA-SS consisted of CSA technology performance index and CSA- implementation feasibility index which are summarized below.

5.2.1 Climate-smart agriculture technology performance index (CSA-PI)

CSA intervention performance was evaluated based on CSA performance index (Khatri-Chhetri et al., 2019). CSA-PI includes the scores given by stakeholders for productivity, income, resilience and emission related indicators against each technology.

$$\text{CSA PI} = \alpha 1 * \text{Productivity (\%)} + \alpha 2 * \text{Income (\%)} + \alpha 3 * \text{Resilience (\%)} - \alpha 4 * \text{Emission (\%)}$$

Where,
CSA-PI=CSA Performance Index, $\alpha 1=0.40$, $\alpha 2=0.30$, $\alpha 3=0.20$ and $\alpha 4=0.10$ are weight for each indicator of CSA taken based on stakeholder's response.
Figure 20 presents stakeholders' evaluation of the selected CSA technologies based on their contribution to improve farm productivity, income, resilience and reduction of emissions. Majority of the water smart technologies such as farm ponds, check dams, drip irrigation, mulching etc. received highest CSA-PI score. Adilabad district frequently receives excess rainfall and as per stakeholder's perception water-smart technologies such as farm pond, check dam, drip irrigation, mulching, raised bed and broad bed planting are required for land and water conservation. As the more water is saved by using these technologies ultimately increases area under irrigation and thereof increases the use of fertilizers. Eventually, this increases the production and farmer's income. Hence, the scores of CSA-PI indicators obtained for water smart technology were high. These water smart CSA technologies are important for building water resilience and reducing adverse impact of climate risks on crop production.

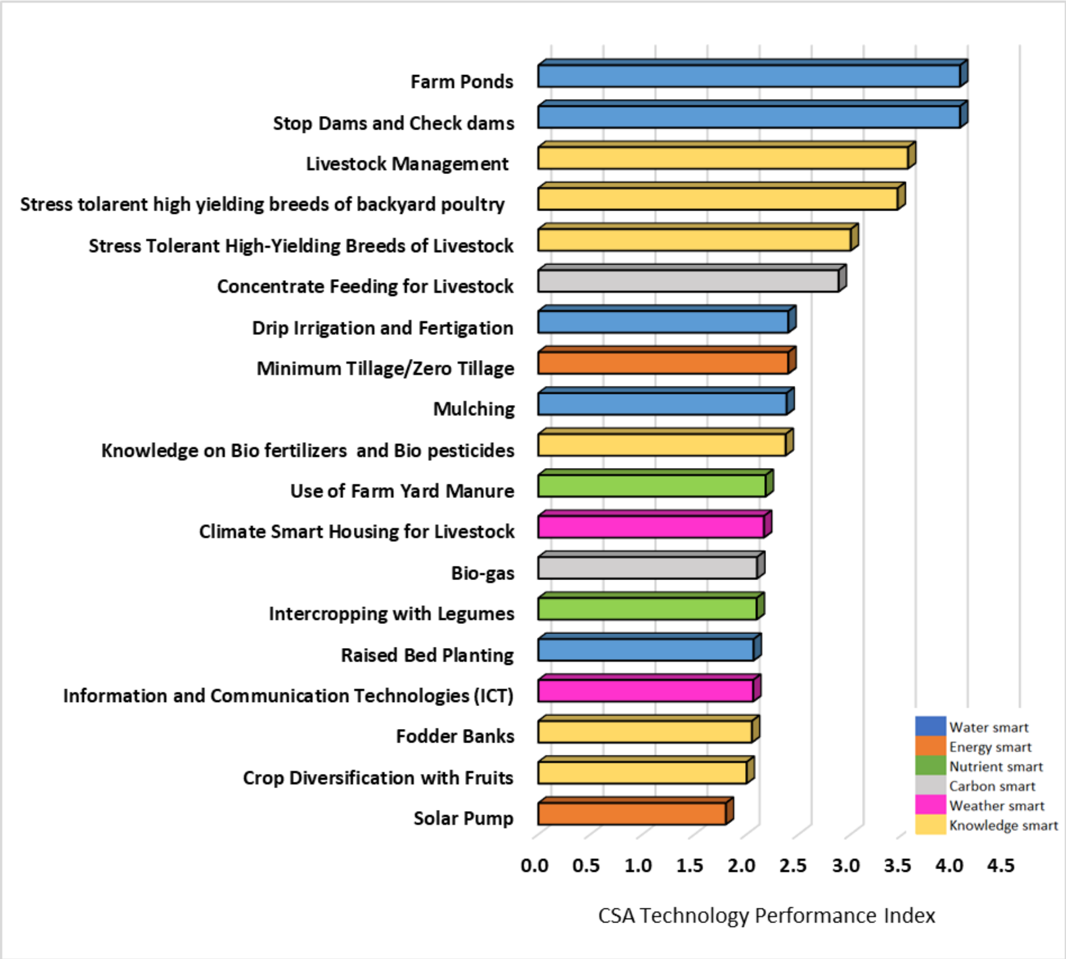

Figure 20. CSA technology performance index

Similarly, Knowledge smart technologies were also ranked with high CSA-PI score, which particularly emphasizes on livestock management technologies. As more area is under rainfed system in Adilabad, livestock and poultry production system is having importance as it provides sustainable income source for small farmers. Knowledge smart technologies such as livestock management, stress tolerant high-yielding breeds of backyard poultry and livestock, area specific mineral mixture and concentrate feeding for livestock were ranked high score CSA-PI. As per the stakeholders' opinion the production score for crop diversification of fruits and fodder is medium but the income generated are low and hence got less CSA-PI score. After knowledge smart technologies, energy smart technologies such as zero tillage, fertigation and nutrient smart technologies like use of FYM, weather smart technologies like climate smart housing for livestock and ICT were also scored good CSA-PI.

The selected list of Climate smart technologies based on high CSA performance index under each category are shown in Figure 21.

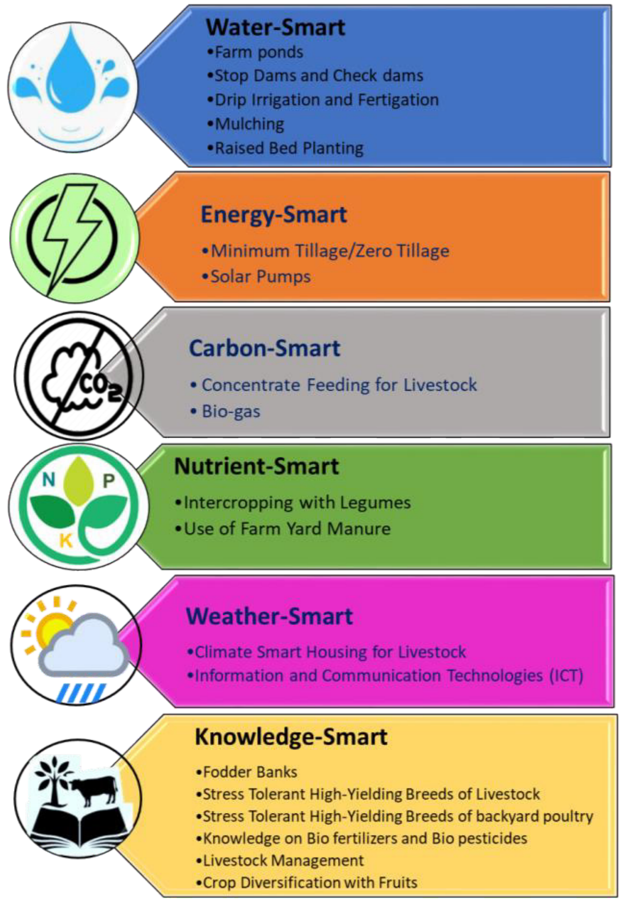

Figure 21. Selected CSA technologies by stakeholder

5.2.2 CSA technology implementation feasibility

Overall implementation feasibility of CSA technologies is based on their technical feasibility, cost of technology, gender inclusivity and synergy with government plans. Implementation feasibility was evaluated by using 0–5 Likert Scale, where 0=not relevant, 1=very low importance, 2=low importance, 3=medium importance, 4=high importance and 5=very high importance. Likert scale is a rating scale commonly used in social science research to evaluate human attitude, which can be considered an interplay of human cognition, feeling and action (Joshi et al., 2015; Udmale et al., 2014).

CSA-IF *= β1* Technical Feasibility Score + β2* Cost Score + β3* Inclusivity Score + β4* Synergy with Government Schemes*

Where,

CSA-IF=CSA Implementation Feasibility, β1=0.35, β2=0.35, β3=0.05 and β4=0.25 are weights estimated based on stakeholder's response.

Results indicated that the overall implementation feasibility was largely influenced by their technical feasibility, cost of implementation and intervention's synergy with government plans.

Figure 22 presents the implementation feasibility of selected CSA interventions.

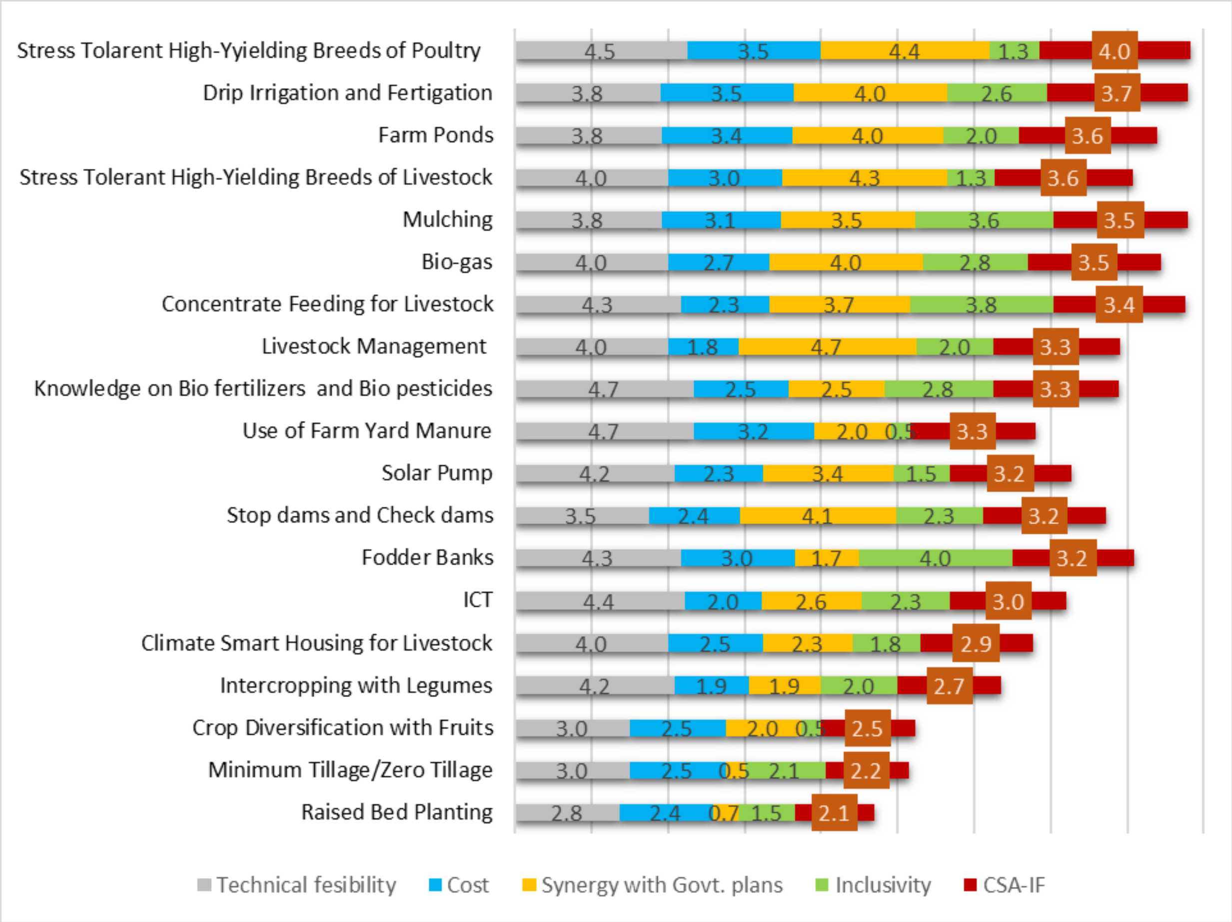

Figure 22. CSA technologies implementation feasibility

Stress tolerant high yielding varieties of livestock and poultry, drip irrigation and fertigation, farm ponds, mulching, bio- gas, concentrate feeding and livestock management, knowledge of bio-fertilizers and pesticides, use of FYM, solar pumps, fodder banks etc. scored high in overall implementation feasibility of technology. Technology implementation feasibility score was found quite in good range for all technologies. Synergy with government and overall cost required for the technologies needs an attention in the implementation of climate adaptation plan of Adilabad district. Inclusivity is not much imperative as the stakeholders has given low score and weightage.

Best bet CSA technologies with high CSA-PI and CSA-IF values included farm ponds, stress tolerant high yielding breeds of backyard poultry, livestock management, stress tolerant high-yielding breeds of livestock, fertigation, area specific mineral mixture for livestock, concentrate feeding for livestock, mulching, drip irrigation, knowledge on bio fertilizers and bio pesticides, bio-gas etc.

5.2.3 Assessment of adoption level and barriers

Selected CSA technologies were evaluated for different adoption level and barriers, if any. Availability of finance, inputs, awareness of technology, awareness and acceptability of technology, government support for adoption of technology, different extension services etc. are key elements of barriers. Many studies indicate that despite technology requirement and farmers' interest to implement, their investment capacity limits adoption of many CSA technologies and practices in agriculture (Gebregziabher et al., 2013; Palanisami et al., 2015).

Adilabad district has significant number of small holder farmers. Farmer's economic condition is one of the main constraints to adopt CSA technologies. Many technologies such as zero tillage, drip irrigation, climate smart housing, bio-gas - require monetary input for implementation in the field. Majority of the smallholder farmers lack access to required farm machinery for timely operation and this becomes one of the key limitation for implementing smart interventions especially when window of carrying out agricultural operations is narrow as is the usual case in such rainfed areas. Some of the government schemes PMKSY, RKVY, MIDH etc. support to implement these technologies. But lack of awareness about the technology, support from government towards investment, and lack of acceptability due to awareness are again the constraints. Extension services are required to create awareness and the knowledge about technology. Analysis also revealed that availability of labor and rainwater are also crucial for the adoption of CSA technologies, practices and services. Figure 23 shows the response of selected CSA technologies to different adoption barriers. Color scale of 0-5 is used to indicate the level of adoption barriers for different indicators. It shows weak financial resource base is a major barrier for the farmers in Adilabad district for adoption of solar pump, concentrate feeding and climate smart housing for livestock, high yielding varieties of livestock and poultry. Similarly, government support is also seen very weak for these interventions. Input availability is very less for intervention adaptability. Other parameters achieved well in terms of rain water, labor availability, acceptability by farmers, extension services etc.

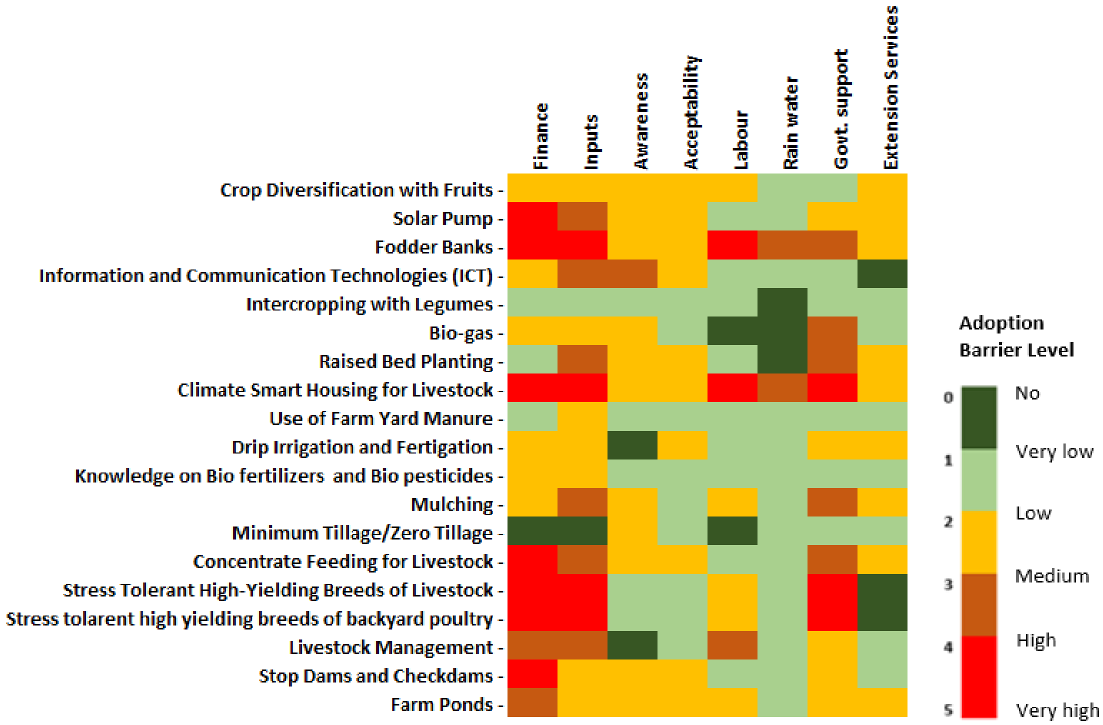

Figure 23. Assessment of adoption level and barriers in implementation of CSA technology

5.2.4 Incentive mechanisms to promote CSA technologies

Incentives such as subsidy in technology, access to affordable farm credit, capacity building and access to market were assessed through CSA prioritization to scale out many CSA technologies at the local level. Table 6 presents stakeholders ranking of incentive mechanisms for scaling out CSA technologies at the local level. The scale of 0–5 was used, where 0=not relevant, 1=very low importance, 2=low importance, 3=medium importance, 4=high importance and 5=very high importance. Subsidy in technology was identified as major incentive mechanism followed by affordable credits to promote CSA technologies such as drip irrigation, bio-gas, solar pump, climate smart housing for animals etc. Capacity building for many CSA technology applications was also identified as another major incentive mechanism to increase farmers' awareness on technologies and building confidence to implement these technologies in their farms. Interventions such as fodder banks, livestock managements, fertigation, stress tolerant breeds of poultry and livestock required farmer's linkage with market.

Table 6. Assessment of different incentive mechanisms required to promote CSA technologies

CSA Technologies	*Subsidy*	*Affordable credit*	*Capacity building*	*Linkage with market*
1. Crop Diversification with Fruits	2.7	1.7	2.3	2.3
2. Solar Pump	4.5	3.4	3.1	2.8
3. Fodder Banks	2.7	1.5	4.0	1.5
4. Information and Communication Technologies (ICT)	2.2	1.6	2.8	0.0
5. Intercropping with Legumes	1.6	1.1	1.8	1.5
6. Bio-gas	5.0	3.0	3.0	2.0
7. Raised Bed Planting	1.7	1.3	4.0	0.0
8. Climate Smart Housing for Livestock	4.3	3.0	2.5	0.5
9. Use of Farm Yard Manure	2.4	2.3	2.6	1.8
10. Drip Irrigation and Fertigation	3.9	3.1	3.9	3.0
11. Knowledge on Bio fertilizers and Bio pesticides	3.0	2.3	3.8	2.0
12. Mulching	4.2	2.1	3.4	2.0
13. Minimum Tillage/Zero Tillage	1.8	2.0	2.0	0.5
14. Concentrate Feeding for Livestock	3.8	3.7	2.7	3.3
15. Stress Tolerant High-Yielding Breeds of Livestock	4.5	4.0	4.0	4.0
16. Stress Tolerant High-Yielding Breeds of backyard poultry	4.5	5.0	5.0	5.0
17. Livestock Management	4.0	4.0	4.0	1.5
18. Stop dams and Check dams	3.3	2.1	3.2	0.0
19. Farm Ponds	4.2	3.0	3.4	1.3

5.2.5 Key institutions to scale out CSA technologies

Multiple institutions play multiple roles at different level for farmers and farming communities with different responsibilities. The institutions such as private sector retailers, NGOs, FPOs help to scale out CSA technologies in rural sector. Role of such organizations in supporting adoption of CSA technologies, practices and services was also evaluated.

Table 7 indicates the ranking of key institutions in scaling out CSA technologies. The scale of 0–5 was used, where 0=not relevant, 1=very low importance, 2=low importance, 3=medium importance, 4=high importance and 5=very high importance. Private sector retailers and NGOs turned out to be the key institutions to scale out information and communication, drip irrigation, mulching, solar pump etc. Custom hiring centers and farmer-producer groups were also identified as key players in promoting some CSA technologies such as crop diversification, concentrate feeding for livestock, intercropping with legumes and farmyard manure. The role of young farmers' group was also identified to be instrumental in promoting CSA technologies at the local level. Women self-help groups were also identified for empowering women about technologies and promoting CSA. It is important to note that these local level institutions have vital role in scaling out climate resilient interventions and help in complementing government support.

Table 7. Key institutions for scaling out CSA technologies

CSA Technologies	CHC	YFG	WSHG	FPO	NGO	PSR
1. Crop Diversification with Fruits	4.0	5.0	4.0	3.0	2.7	3.0
2. Solar Pump	2.4	2.4	1.8	2.6	2.3	3.2
3. Fodder Banks	2.0	2.0	2.0	3.0	3.0	3.0
4. Information and Communication Technologies (ICT)	0.0	1.8	1.8	1.6	1.6	2.3
5. Intercropping with Legumes	0.5	3.0	2.0	3.0	2.0	2.5
6. Bio-gas	0.5	1.0	1.5	1.5	1.5	1.5
7. Raised Bed Planting	2.0	0.0	0.0	2.0	2.0	3.0
8. Climate Smart Housing for Livestock	1.0	2.0	2.5	3.0	3.0	1.0
9. Use of Farm Yard Manure	2.0	1.0	2.5	2.0	2.0	2.0
10. Drip Irrigation and Fertigation	0.4	2.2	2.0	2.3	2.3	2.6
11. Knowledge on Bio fertilizers and Bio pesticides	1.0	3.0	3.0	3.0	3.0	3.0
12. Mulching	0.5	1.8	1.8	1.8	1.5	2.0
13. Minimum Tillage/Zero Tillage	1.0	1.0	1.0	1.0	1.0	2.3
14. Concentrate Feeding for Livestock	1.0	3.0	2.0	3.0	3.0	3.0
15. Stress Tolerant High-Yielding Breeds of Livestock	0.0	3.0	2.5	2.5	1.0	0.0
16. Stress Tolerant High-Yielding Breeds of backyard Poultry	1.0	2.0	3.0	2.0	1.0	2.5
17. Livestock Management	0.0	2.0	2.0	2.0	2.0	1.0
18. Stop Dams and Check dams	0.0	2.3	2.0	2.0	2.5	0.7
19. Farm Ponds	0.4	2.4	1.7	1.8	2.5	0.6

CHC: Custom Hiring Centers, YFG: Youth Farmers Groups, WSHG: Women Self Help Groups, FPO: Farmer Producer Organizations, NGO: Non-Government Organizations, PSR: Private Sector Retailers

5.3 CSA evidence framework

Many CSA technologies prioritized are being adopted on farmers' field in Adilabad district. The evidence collected from field demonstrates usefulness of CSA practices to maintain yield levels and increase farmers' income. Crop rotation, intercropping, integrated nutrient management, high yielding seed varieties and raised bed technologies are some of the crucial CSA technologies found functional with significant evidence of enhancing resilience in Adilabad district.

Evidences for climate-smart agriculture technologies implemented in the district/ blocks by KVK/ research Institutes/ station in agriculture and allied sectors in the areas of natural resource management, crop/ horticultural production systems, livestock and fisheries production systems are given in the Table 8:

Table 8. Evidences from climate-smart agriculture practices implemented in Adilabad district

S. No.	Crop	Intervention implemented	Farming situation in block	Year	Season	Cost of intervention (Rs/ha)	Yield (kg/ha)		Net Returns (Rs/ha)		BC ratio
							Demo	Check	Demo	Check	
1.	Cotton	Balanced application of nutrients in cotton for higher production	Rainfed, Black Soil	2014	*Kharif*	47475	**Demo:** 20.75	**Check:** 19.00	35525	27600	**Demo:** 1.7:1 **Check:** 1.57:1
2.	Cotton	Intercropping systems in cotton	Rainfed, Black Soil	2014	*Kharif*	53050	**T2: Demo**: 17.32 + 3.00	**T1: Farmers Practice : **22.37+ 5.67	**T2:** 35625	**T1:** 37750	**T1**:**Check** : 2.19:1 **T2:Demo** : 1.48 :1
3.	Red gram	Introduction of improved variety in Red gram (PRG-158)	Rainfed, Black Soil	2014	*Kharif*	16250	**Demo:** 11.25	**Check:** 9.30	42250	32110	**Demo:** 3.6:1 **Check:** 2.97:1
4.	Red gram	Demonstration on improved Red gram varieties (PRG-176)	Rainfed / Black soils	2016	*Kharif*	25269	**Demo:** 23.25+ 2.75	**Check:** 22.50+ 2.00	29521	26851	**Demo: 2.16:1 Check: 2.07:1**
5.	Red gram	Demonstration on improved Redgram varieties) PRG-176)	Rainfed, Black Soil	2017	*Kharif*	53350	**Demo:** 18.41+ 5.50	**Check:** 18.00 + 3.75	54709	45013	**Demo:** 2.03:1 **Check:** 1.83:1
6.	Green gram	Introduction of High yielding green gram Variety (WGG-42)	Rainfed, Black Soil	2016	*Kharif*	7308	**Demo: 1**1.50	**Check:** 10.00	12012	9492	**Demo:** 2.64:1 **Check:** 2.29:1
7.	Bengal gram	Popularization of improved variety in Bengal gram (NBeG-3)	Irrigated, Black Soil	2014-15	*Rabi*	24500	**Demo:** 19.00	**Check:** 17.50	40100	35000	**Demo:** 2.63:1 **Check:** 2.42:1
8.	Soybean	Demonstration on improved soybean variety	Rainfed, Black Soil	2015	*Kharif*	28652	**Demo:** 18.75	**Check:** 10	38847	9535	**Demo:** 2.35:1 **Check:** 1.36:1

		(Basara) in Adilabad district									
9.	Turmeric	Cultivation of Turmeric through raised bed system	Rainfed / Black soils	2016	*Kharif*	221638	**Demo:** 100.00/ ha dry yield	**Check:** 65.00 q/ha dry yield.	828363	460863	**Demo:** 2.9:1 **Check:** 2.4:1
10.	Turmeric	Cultivation of Turmeric through raised bed system	Irrigated Black soils	2017	*Kharif*	1152096	**Demo:** 148.25	**Check:** 70.00	813596	282725	**Demo:** **3.4:1** **Check:** **2.0: 1**
11.	Tomato	Poly mulching in Tomato	Irrigated Red soils	2015	*Kharif*	257625	**Demo:** 937.50	**Check:** 750	1054875	705875	**Demo:** 5.1:1 **Check:** 4.6:1
12.	Tomato	Poly mulching in Tomato	Rainfed / Black soils	2016	*Kharif*	237625	**Demo:** 750.00	**Check:** 500.00	437375	218875	**Demo:** 2.8:1 **Check:** 2.4:1

5.3.1 Evidence of climate smartness for cropping system

Cotton is major crop grown under all the blocks of Adilabad district in rainfed system on black soil. Bt-Cotton is commonly used variety. In view of presence of a greater number of cotton ginning and pressing industries available in the district, there is a good scope for production of export-oriented quality lint and also cotton seed oil through existing oil mills. Mono cropping, cultivation of cotton on shallow and marginal soil, dry spells and drought, waterlogging, lack of knowledge on pest and disease management are some of the identified problems in raising cotton. Soil Test Crop Response (STCR) based fertilization, intercropping system and introduction of high yielding varieties are some of the CSA practices used for cotton crop and have proved advantageous in terms of gaining more yield and returns, with BC ratio of over 1.5:1.

Soybean is second important crop cultivated on black soil during *kharif* season in rainfed system. Adilabad district with 39.6% area under soybean is producing 38.2% of total states' soybean production. As 43 edible oil mills are located in different parts of the district and involved in extracting edible oil from soybean seeds, there is an ample scope for production of soybean based premium value-added nutritious food products in the district. Demonstration of improved soybean variety (Basara) and use of new farm technologies are the relevant smart technologies in the area. Red gram and green gram are also grown in *kharif* season with some improved variety of seeds and all evidenced BC ratio of over 2:1.

Tomato and turmeric are also other important crops grown in *kharif* season. Tomato is mostly cultivated using poly mulching system with drip irrigation and having BC ratio more than 2.5:1.

Turmeric is one of the commercial crops grown on raised bed planting system with over 3:1 BC ratio.

In *rabi* season, Jowar and Bengal gram are the main crops grown on black soil in irrigated system. Lack of awareness about modern agricultural practices and pest management are the key problems in growing these crops. In Bengal gram, improved varieties and seed to seed mechanization are few CSA practices followed by farmers. The benefit cost ratio for Bengal gram is more than 2.6:1.

5.3.2 CSA Evidence for livestock and poultry

Use of mineral mixture and concentrate feeding has evidenced increased body weight of animals by 10-12 % and milk production by 116%. Introduction of improved variety of breed of poultry such as Grampriya and backyard poultry systems proved better for increasing egg production by 150%. Since the district is having more than 25% of the total district population is tribes. Hence, there is a scope for backyard poultry in tribal Gudams for assured subsidiary income to the family and nutritious eggs for domestic consumption as well.

In summary, intercropping, fertigation, use of improved varieties, IPM, IPNM, drip irrigation, mulching etc. are the CSA practices being mostly practiced in the Adilabad district with better results. Farm ponds, minimum tillage/zero tillage, use of FYM, knowledge of bio-fertilizers, bio-pesticides etc. are some other significant prioritized CSA technologies for cropping system. As drought is a major risk in Adilabad district, stress tolerant breeds of livestock and poultry, fodder banks and climate smart housing are also required for sustainable production in dry season.

6. Scaling up at district level

To scale out the area specific CSA technologies for resilient farming and sustainable production under climate change, convergence with ongoing development schemes and programmes is critical. This section focuses on funds/investments required for scaled up implementation of these CSA technologies and convergence possibilities with existing functional government schemes for upscaling.

6.1 Estimated Funds requirement

Total cost of the proposed project in scaling out CSA technologies for resilient farming is estimated based on number/area of potential CSA practices and interventions required in the district. Number/area of prioritized CSA technologies are based on certain assumptions (in Table 9) reflecting the demonstration scale required for effective dissemination and upscaling. Area under different crops is taken as average of latest 3 years' data as given in Appendix-6 and the 508 number of villages from Adilabad districts are considered for estimating costs. However, these numbers may vary when actual implementation plan is prepared with more micro level fine tuning at sub-district level. Table 9 gives an individual intervention's cost with proposed numbers/area under intervention.

Table 9. Cost and total number/area of individual CSA practices across different smartness component

Intervention	Total number/ area	Unit	Total cost (Crore)	Basis
Water-Smart				
Farm Ponds	5040	no.	50.4	10 FP per village.
Stop Dams and Check dams	250	no.	25.0	10% of rainfed area and 1CD/10ha.
Drip Irrigation and Fertigation	25000	Ha	143.0	In 25 % of non-paddy, non-cereal crops area (includes cotton, red gram, vegetable and orchard area).
Mulching	2000	Ha	6.0	50% of vegetable and fruit crops area.
Raised Bed Planting	12000	Ha	7.4	In 25 % of wheat, red gram, black gram, Bengal gram and vegetable area.

Broad Bed Furrow (BBF) Planting[4]	504	No.	2.0	1 unit of BBF planter in each village
Water-smart technologies total cost = Rs. 233.8 Cr.				
Energy-Smart				
Minimum Tillage/Zero Tillage	300	Ha	0.2	includes machine labour/ rent cost (25% of Maize cultivated area)
Solar Pumps	500	no.	25.0	Replacement of 500 existing pumps.
Energy-Smart technologies total cost = Rs. 25.2 Cr.				
Nutrient-Smart				
Intercropping with Legumes	2520	Ha	2.5	Area coverage- 5 ha/village
Use of Farm Yard Manure	2520	Ha	2.5	Area coverage- 5 ha/village
Nutrient-Smart technologies total cost = Rs. 5.0 Cr.				
Carbon-Smart				
Concentrate Feeding for Livestock	10000	no.	0.7	20 animals / village
Bio-gas	1008	no.	1.5	2 bio-gas plants/village
Carbon-Smart technologies total cost = Rs. 2.2 Cr.				
Weather-Smart				
Climate Smart Housing for Livestock	50	no.	2.5	One unit per 10 villages
Information and Communication Technologies	80	no.	2.4	One unit per 50 sq.km
Weather-Smart technologies total cost = Rs. 4.9 Cr.				
Knowledge-Smart				
Fodder Banks	504	Ha	0.2	1ha/village
Stress Tolerant High-Yielding Breeds of Livestock	100	no.	0.6	5-6 animal per block
Stress Tolerant High-Yielding Breeds of backyard poultry	50	no.	0.8	1 poultry unit per 10 villages
Knowledge on Bio fertilizers and Bio pesticides	1000	no.	0.1	Training to 1000 farmers
Livestock Management	500	no.	0.1	Training to 1000 farmers
Crop diversification with fruits	1000	no.	0.1	Training to 1000 farmers
Knowledge-Smart technologies total cost = Rs. 1.7 Cr.				

[4] After review and based on experts input BBF is additionally considered for land conservation measures.

Total cost of implementation of CSA project is estimated to be Rs. 273.0 crore. The major part of the total cost is required for the implementation of CSA practices in water smart and energy smart components with Rs. 233.8 Cr. and Rs. 25.2 Cr. respectively, as it involves construction of infrastructures (farm ponds, check dams, bio-gas, solar pump etc.) and farm equipment/ measures for land and water conservation whereas practices in other climate smart components are largely having demonstrations and capacity building. However, cost doesn't signify the importance of a given smartness component as integrated application is needed to maximize the benefits as standalone implementation would not build required level of resilience to climate change.

6.2 Convergence of existing government schemes and plans

Planning and implementation of prioritized CSA interventions for resilient agriculture in a district requires huge resources and this often becomes a constraint. While it is also apparent that different government departments at the district level are having a number of development schemes with significant resources for implementing a variety of activities and works those are relevant for climate-smart agriculture. To optimize public investments made under existing schemes through convergence of resources for a common/shared goal of building resilience we require to establish synergy within these investments. Government is also pushing the agenda of convergence as a policy instrument to make resources from various schemes complementary to one another rather than duplicity and thin distribution of resources. This will help in leveraging and integrating resources from relevant agriculture and rural development programs for providing critical mass for scaling out climate resilient agriculture at development scale.

Through convergence, available and existing resources under different schemes will be targeted in a more integrated manner to develop and implement district climate-smart agriculture plan for resilient agriculture. It is aimed at bringing convergence of both financial and human resources of different programmes/schemes and institutions implemented by different departments. It is proposed that during the project planning and pre-implementation phase, project partners/ district line departments come together to plan, discuss and finalize the convergence matrix as well as process guidelines.

Several schemes of the state and central government under implementation have considerable scope for piloting their activities in convergence with CSA. In the proposed convergence plan, CSA practices are mapped to existing government schemes and departments for implementation within the permissible activities/works and parameters of that particular scheme as per the respective guidelines. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) *har khet ko pani and more crop per drop*, Weather based Crop Insurance Scheme (WBCIS), Rashtriya Krishi Vikas Yojana (RKVY), Rainfed Area Development Program (RADP)- National Mission for Sustainable Agriculture (NMSA), Mission Kakatiya etc. are some potential schemes for convergence in

Adilabad district. These government schemes with the possibility of convergence to establish synergy for optimized use of resources for a common/shared cause of making agriculture resilient are listed in table 10. There could be even few more that may opportunity for convergence on case by case basis.

Table 10. Convergence of existing govt. schemes and plans with selected CSA technologies

Intervention/Technology/Practice/Services	Govt. scheme name
Water-Smart	
1. Farm pond	Mahatma Gandhi NREGA, *Mission Kakatiya and* Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)-*Har khet ko pani*
2. Stop Dams and Check dams	Mahatma Gandhi NREGA and Mission Kakatiya
3. Drip Irrigation and Fertigation	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)-*Per drop more crop*
4. Mulching	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)-*Per drop more crop*
5. Raised Bed Planting	Farm Mechanization component of Normal State Plan (FM-NSP)
6. Broad Bed Furrow (BBF) Planting	Farm Mechanization component of Normal State Plan (FM-NSP)
Energy-Smart	
1. Minimum Tillage/Zero Tillage	Rashtriya Krishi Vikas Yojana (RKVY)
2. Solar Pumps	MNRE-Solar off grid
Nutrient-Smart	
1. Intercropping with Legumes	National Food Security Mission (NFSM)
2. Use of Farm Yard Manure	Rainfed Area Development RAD- NMSA
Carbon-Smart	
1. Concentrate Feeding for Livestock	Rainfed Area Development RAD- NMSA
2. Bio-gas	MNRE-Biogas based Distributed/Grid Power Generation Programme (BPGP)
Weather-Smart	
1. Climate Smart Housing for Livestock	Rainfed Area Development RAD- NMSA
2. Information and Communication Technologies (ICT)	National e-Governance Plan in Agriculture (NeGP-A)
Knowledge-Smart	
1. Fodder Banks	Rainfed Area Development RAD- NMSA

2. Stress Tolerant High-Yielding Breeds of Livestock	Rainfed Area Development RAD- NMSA
3. Stress Tolerant High-Yielding Breeds of backyard poultry	Rainfed Area Development RAD- NMSA
4. Knowledge on Bio fertilizers and Bio pesticides	National Food Security Mission (NFSM)
5. Livestock Management	Rashtriya Krishi Vikas Yojana (RKVY)
6. Crop diversification with fruits	Mission for Integrated Development of Horticulture

The CSA technologies such as ICT, solar pump, bio-gas, intercropping with legumes and knowledge on bio-fertilizers and pesticides are not having any linkage with existing government plan functioning in Adilabad district. Therefore, the need arises to find suitable schemes for providing required funding for the implementation of these technologies. Alternatively, additional resources will have to be mobilized for implementing these climate smart interventions.

Some amount of funds is already available in the selected government schemes and details are given in Appendix- 4. The funds required from government to implement CSA is estimated based on the relevant guidelines of the schemes for respective CSA interventions. The details used for estimating government contribution through each scheme are given in Appendix-6. This estimate is compared with the available funds in each of these schemes. Table 11 gives the details of funds available, required and the gap in funding requirement for implementation of adaptation plan.

From the Table 11 it is understood that the available funds through different schemes is Rs. 321.3 Cr. which includes major share of Mission Kakatiya scheme of 308.8 Cr. The fund needed from government for the implementation of district level climate adaptation plan implementation is estimated at Rs. 132.8 Cr. The funding gap of Rs. 61.1 Cr. needs to be arranged from different technology relevant schemes. PMKSY is playing major role in implementation of CSA with its sub component of *Har Khet ko Pani* and *Per Crop More Drop.* In this plan, MNRE-Solar off grid, MNRE-Biogas based Distributed/Grid Power Generation Programme (BPGP), National e-Governance Plan in Agriculture (NeGP-A) and National Food Security Mission (NFSM) are proposed additionally to link with ICT, solar pump, bio-gas, intercropping with legumes and knowledge on bio-fertilizers and pesticides as presently these do not exist in the district. The current approach of providing funds through different schemes needs to be re-visited based on prioritized best applicable CSA technologies in Adilabad district

Table 11. Funds required from the government schemes and top up for viable gap in funding for implementation of CSA plan

Government Schemes	Funds Available (Rs. Cr.)	Matched technologies	Government support required as per CSA plan (Rs. Cr.)	Funding gap (Rs. Cr.)
Mahatma Gandhi NREGA, Mission Kakatiya and PMKSY-Har Khet ko pani	308.8+ 2.5	Farm pond, Stop Dams and Check dams,	65.0	-
RAD-NMSA	0.4	Use of Farm Yard Manure, Concentrate Feeding for Livestock, Climate Smart Housing for Livestock, Fodder Banks, Stress Tolerant High-Yielding Breeds of Livestock and Poultry	2.3	1.9
RKVY	0.8	Zero Tillage, Livestock Management	0.2	-
MIDH	0.6	Crop diversification with fruits	0.1	-
PMKSY-Per drop more crop	8.2	Drip Irrigation, Mulching and Fertigation	56.0	47.8
Farm Mechanization component of Normal State Plan (FM-NSP)	NA	Raised Bed Planting and Broad Bed Furrow Planting	1.0	1.0
National e-Governance Plan in Agriculture (NeGP-A)	NA	Information and Communication Technologies (ICT)	2.4	2.4
MNRE-Solar off grid	NA	Solar Pumps	5.0	5.0
MNRE-Biogas based Distributed/Grid Power Generation Programme (BPGP)	NA	Bio-gas	0.4	0.4
National Food Security Mission (NFSM)	NA	Intercropping with Legumes, Knowledge on bio-fertilizers and pesticides	2.6	2.6
Total Rs. Cr.	**321.3**	**-**	**132.8**	**61.1**

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7. Institutional arrangement and way forward for implementation

The District Climate Adaptation Plan for Resilient Farming is to be implemented at the ground level by district authorities following an institutional arrangement with Krishi Vigyan Kendra of the district as a facilitator and nodal agency for capacity building activities. CCAFS and CG Centres and ICAR/SAUs can help in mentoring from time to time in planning field implementation. While implementing the plan, climate risk prone and most vulnerable mandals/blocks will be given priority for implementation. ICAR institutes located in the vicinity will have key role in advising district authorities in translating this plan to implement on the ground and help in needs based fine tuning of the plan at the sub-district level. ICAR institutes and key SAUs experts would provide knowledge support, build capacity of field officials together with KVK and CG Centres and required guidance during field implementation from time to time. It will be better to form a small Advisory Group at the district level.

Integrating the physical, institutional, social and economic capital is key for comprehensive development at the district and sub-district level. The process of convergence of institutions and resources should ideally start right from the pre-planning stage itself. Collective planning and implementation among different departments/sectoral institutions will enhance social capital, common and shared understanding for improved planning, implementation and management. The convergence matrix must clearly identify source(s) of funding for each type/nature of activity/work including the quantity. All the central and state government schemes have their respective guidelines with a multi-level institutional structure where responsibilities such as guiding principles, finance, planning, admissibility of works/activities, entitlements, identification of beneficiaries and implementation procedures are explained. For smooth implementation therefore, a suitable institutional arrangement/mechanism is crucial at the district, block and GP level.

District level Program Implementation and Coordination Committee (DPIC) is proposed to be formed, headed by the District Collector/District Magistrate or Chief Development Officer (CDO)/CEO (ZP) to coordinate, guide, approve, oversee and monitor the project at district level. The Committee will have district level officials representing line departments responsible for implementing schemes for agriculture, rural development, animal husbandry, irrigation/water resources, groundwater, and other key schemes likely to be converged, and representative from district KVK. Representatives responsible for implementing other need based schemes as per local needs of CSA components may be co-opted. Similar institutional arrangements in the form of committees with all relevant departments and implementing organizations will need to be formed at the block and GP levels.

Such institutional arrangement ensures smooth and effective collaboration of government and non-government organizations. This would also ensure collective responsibility at all levels of project implementation and devolution of responsibilities to the most appropriate level.
Key players from relevant line departments should be involved in the joint field visits, planning and preparation of detailed local area action plans with a clear convergence matrix indicating source(s) for leveraging funds for given components from respective schemes. The convergence matrix must clearly identify source of funding for each type/nature of activity/work including the quantity.

The project is proposed to be rolled out in 18 Mandal's/Blocks over a period of five years (an example scenario given in Appendix-7).
The activities can be divided into three phase for smooth and optimized implementation of the district level plan that ensures maximum benefits.

Pre-implementation/planning phase: (1 year)

- Final selection of villages where CSV approach would be implemented based on set of indicators discussed in the report. This would involve wider consultation with government and field level implementing organizations and local community and NGOs.
- Rapport building to optimize the benefits of CSVs- it is essential and necessary that village communities understand and accept the project. Thus, a critical step in pre-implementation would be wider consultations with village community and community level organizations to build awareness.
- Capacity building of officials and training of implementing organization(s)
- Beneficiary selection where the CSA plan would be implemented
- Baseline study for agro-ecological and socio-economic context

Implementation phase (3-5 year):

- Implementation of CSA plan on field level in a coordinated manner by line departments and village level organizations.
- Regular monitoring according to pre-planned approach and reporting

Post-implementation phase (1 year):

- Impact assessment and evaluation: through the implementation phase and post implementation, extensive data would be collected though household and farm level surveys and discussions to evaluate impacts.

  Dissemination of outcomes: comprehensive result dissemination plan be developed that would include but not limited to workshops with relevant stakeholders, use of social media, blogs and articles.

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Appendix 1

Details of block wise cropping system and different risk vulnerabilities.

Sr. No.	Block/ tehsil/ mandal	Cropping system	Crop name	Season	Vulnerability	Period of occurrence
1	Adilabad (Rural)	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton – Jowar	Cotton, Red gram, Soybean, Jowar	*Kharif* / *Rabi*	Dry spells Hail storms	July – August
2	Adilabad (Urban)	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Red gram, Soybean, Jowar	*Kharif* / *Rabi*	Dry spells Hail storms	July – August
3	Bazarhathnoor	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram	*Kharif* / *Rabi*	Dry spells, waterlogging	July – August
4	Bela	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton – Jowar Soybean – Bengal gram	Cotton, Soybean, Red gram, Bengal gram	*Kharif* / *Rabi*	Dry spells, Temporary waterlogging	July – August
5	Bheempur	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton – Jowar Soybean – Bengal gram	Cotton, Soybean, Red gram, Bengal gram	*Kharif* / *Rabi*	Dry spells	July – August
6	Boath	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram, Jowar	*Kharif* / *Rabi*	Dry spells Waterlogging	July – August
7	Echoda	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram	*Kharif* / *Rabi*	Dry spells Waterlogging Cold injury	July – August July – August December – January
8	Gadiguda	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram, Jowar	*kharif* / *Rabi*	Dry spells	July – August
9	Gudihatnoor	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow	Cotton, Soybean, Red gram	*kharif* / *Rabi*	Dry spells Hail storms	July – August March

		Soybean – Jowar Cotton - Jowar				
10	Indervally	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram, Jowar	*kharif* / *Rabi*	Dry spells	July – August
11	Jainath	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean	*kharif* / *Rabi*	Dry spells Water logging Floods Cold injury	July – August December – January
12	Mavala	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean	*kharif* / *Rabi*	Dry spells	July – August
13	Narnoor	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram, Jowar	*kharif* / *Rabi*	Dry spells	July – August
14	Neradigonda	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram	*kharif* / *Rabi*	Dry spells	July – August
15	Sirikonda	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram	*kharif* / *Rabi*	Dry spells	July – August
16	Talamadugu	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton – Jowar Soybean – Bengal gram	Cotton, Soybean, Red gram, Bengal gram	*kharif* / *Rabi*	Dry spells	July – August
17	Tamsi	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton – Jowar Soybean – Bengal gram	Cotton, Soybean, Red gram, Bengal gram	*kharif* / *Rabi*	Dry spells Hail storms	July – August March
18	Utnoor	Cotton – fallow Soybean – fallow Cotton + Redgram – fallow Soybean – Jowar Cotton - Jowar	Cotton, Soybean, Red gram	*kharif* / *Rabi*	Dry spells	July – August

Appendix 2

List of CSA technologies suitable for different crops and cropping systems

Technology/Practice/Services	How it help to adaptation/mitigation of climatic risks
Water-Smart	***Technologies that improve Water-Use Efficiency***
1. Dugout Ponds and Storage Tanks	Collection of rainwater not allowing to run-off and use for agriculture in rainfed/dry areas and other purposes on site.
2. Rooftop Rainwater Collection	Provides good opportunities for augmenting the common pool of groundwater resources.
3. Nala Bunding	Impounds surface runoff coming from the catchments and stabilize the *nala* grade to facilitate percolation of stored water into the soil sub-strata with a view to raise ground water level
4. Stop Dams and Checkdams	Small water storage structures constructed across small streams or *nallas* to collect and impound the surface runoff from catchments of the streams during monsoon season.
5. Diversion Channels	Diversion channel is a simple excavated long structure to convey water from a higher elevation to the point of storage or use near the habitation.
6. Drip Irrigation	Application of water directly to the root zone of crops and minimize water loss
7. Sprinkler	The system can supply small and uniform application on demand and meet the emergent situations of climatic aberrations. The water application is controlled and only the required amount of needed water is applied by the system.
8. Alternate Wetting and Drying (Rice)	Need based application of water in the rice filed, minimize overuse of water. Saves water and energy use
9. Furrow Irrigated Bed Planting	This method offers more effective control over irrigation and drainage as well as rainwater management during the monsoon (also improves nutrient use efficiency)
10. Conservation Furrow	Conserve water and allows better drainage and run-off
11. Raised Bed Planting	Conserve water and allows better drainage and run-off
12. Drainage Management	Removal of excess water (flood) through water control structure
13. Farm Bunding	Decrease the length of the slope and help in intercepting the runoff flowing down the slope thereby conserving moisture and reducing soil erosion
14. Vegetative Contour Barriers	Planted with perennial grasses and shrubs, the barriers reduce runoff velocity and increase infiltration opportunity time and also trap fine soil and nutrients.
15. Laser Land Levelling	Quick and more effective land levelling practice which modifies the land surface to a planned grade or zero grade to provide a suitable field surface for controlling flow of water, check soil erosion, provide improved surface drainage, conserve moisture and ensure uniform application and distribution of water and nutrients.

16. Mulching	Mulch is any type of material that is spread or laid over the surface of the soil as a covering. It is used to retain moisture in the soil, suppress weeds, keep the soil cool, and make the garden bed look more attractive. Organic mulches also help improve the soil's fertility, as they decompose. e.g. Bark, compost, composted manure, newspaper, straw etc.
17. Conservation Trenches (sallow and deep)	Artificially dug trenches along the contour line, water flowing down the hill is retained by the trench and infiltrating the soil below.
18. Irrigation Scheduling	Planning when and how much water to apply in order to maintain healthy plant growth during the growing season.
19. Aquifer Recharge Shaft and wells	Used to recharge both the shallow aquifers located below clayey surface and deep aquifers by conveying water from surface (surplus runoff from runoff, reservoirs, storm water, tank, canal etc.) to aquifers.
20. Gully Control Structures like Gabion Structure	These are structures made to control soil erosion. They are simple in construction, flexible, self-draining and are made of construction materials locally available. These structures are cheaper than conventional structures and yet quite effective.
21. Dug well	Water extraction structure to provide water for irrigation
22. Tube wells	Device for obtaining water from beneath the ground. Most ideal for tapping high yielding confined granular aquifers occurring at considerable depths.
23. Wells in stream /river beds	These wells are typically of shallow depth of 10-15 feet in depth in the ground and about 3-4 feet above ground. During the rainy season, the structures remain submerged under the water and supply water during the winter and summer season
24. Cultivation of Millets in light soils	Cultivation of millets requires less water
25. Recycling of crop residues (Cotton stalks)	Recycling of crop residues enhances soil fertility intern increase the absorption of water
26. Increase of crop intensity through intercropping	Under *rain fed* situation water use efficiency is more when increased the crop intensity through intercropping
Energy-Smart	*Technologies that improve Energy-Use Efficiency*
1. Minimum Tillage/Zero Tillage	Reduces amount of energy use in land preparation. In long-run, it also improves water infiltration and organic matter retention into the soil
2. Solar Pumps	Increased access to power through renewable energy; adaptation and mitigation
3. Wind Turbines	Using wind power to lift water for irrigation
4. Wind Mills	Water lifting from wells by wind mills for irrigation
5. Ram Pump	Lifting of flowing water in river or canal by ram pump on no fuel cost
6. Direct Seeded Rice	Requires less water compared to traditional transplanting

7. Drudgery reduction technologies for Farm women	Ergonomic and drudgery reduction technologies for farm women to reduce individual energy loss and increasing of mechanization from seed to plate
Nutrient-Smart	*Technologies that improve Nutrient-Use Efficiency*
1. Green Manuring	Growing and incorporating legume biomass into soil. This practice improves nitrogen supply and soil quality.
2. Intercropping with Legumes	Cultivation of legumes with other main crops in alternate rows or different ratios. This practice improves nitrogen supply and soil quality
3. Use of Farm Yard Manure	Type of organic manure which is a varying mixture of animal manure, urine, bedding material, fodder residues, and other components
4. Use of Vermi-compost	Organic manure (bio-fertilizer) produced as the vermicast by earth worm feeding on biological waste material; plant residues.
5. Integrated Plant Nutrient Management	Involves the application of organic, inorganic and bio-fertilizers in a balanced manner so as to fully meet the requirements of all the major, secondary and micro nutrients for the given crop/ cropping system.
6. Site Specific Nutrient Management using Leaf Colour Chart	Quantify the required amount of nitrogen use based on greenness of crops. Mostly used for split dose application in rice but also applicable for maize and wheat crops to detect nitrogen deficiency
7. Site Specific Nutrient Management using Greenseeker	Optimum supply of soil nutrients over time and space matching to the requirements of crops with right product, rate, time and place
8. Crop Residue Incorporation	Incorporating crop residues like leaves, stems and seed pods into the ground, instead of burning. It can be helpful to mitigate GHGs and also help in nutrient management.
9. Crop Rotation	Crop rotation is the systematic planting of different crops in a particular order over several years in the same growing space. This process helps maintain nutrients in the soil, reduce soil erosion, and prevents plant diseases and pests.
10. Fertigation	Applying of nutrients through drip system at different intervals. This Process helps the nutrient use efficiency.
Carbon-Smart	*Technologies that reduce GHG emissions*
1. Agro Forestry/Fodder Trees	Promote carbon sequestration including sustainable land use management
2. Concentrate Feeding for Livestock	Reduces nutrient losses and livestock requires low amount of feed
3. Integrated Pest Management/Organic Pesticides	Reduces use of chemicals
4. Bio-gas	Reduced methane emissions and fossil fuel use
5. Prophylaxis & Area Specific Mineral Mixture for Livestock	Livestock better withstand abiotic stresses

6. Crop Residue Incorporation (Cotton)	Incorporating crop residues like cotton stubbles into the ground, instead of burning. It can be helpful to mitigate GHGs and also help in nutrient management.
7. Cultivation of Pulses	By producing a smaller carbon footprint pulses indirectly reduce greenhouse gas emissions
8. Bund planting with Horticulture and forest plants	Promote carbon sequestration and income generation to the farmers.
Weather-Smart	*Technologies that provide services related to income security and weather advisories to farmers*
1. Climate Smart Housing for Livestock	Protection of livestock from extreme climatic events (e.g. heat/cold stresses)
2. Information and Communication Technologies (ICT)	Advance climate information help reduce climate risk or take advantage of better seasons
3. Crop Insurance	Crop-specific insurance to compensate income loss due to vagaries of weather
4. Livestock Insurance	Livestock specific insurance provided as a compensation for loss of livestock due to natural calamities/disease/accident
Knowledge-Smart	*Use of combination of science and local knowledge*
1. Contingent Crop Planning	Climatic risk management plan to cope with major weather related contingencies like drought, flood, heat/cold stresses during the crop season
2. Improved/Short Duration Crop Varieties	Crop varieties that are tolerant to drought, flood and heat/cold stresses
3. System for Rice Intensification (SRI)	Reduce water requirement, increase productivity, and build resilience
4. Fodder Banks	Conservation of fodders to manage climatic risks
5. Seed Systems/Banks	Ensuring farmers access to climate ready cultivars
6. Stress Tolerant High-Yielding Breeds of Livestock	Livestock breed that perform better under climatic stress/drought
7. Livestock & Fishery as Diversification Strategy	Reduce risk of income loss due to climate variability
8. Crop Diversification with Fruits	Growing fruits orchards along with other crops. Helps to augment income.
9. Crop Diversification with Vegetables	Growing vegetables along with other crops. Helps to augment income.
10. Pest disease and Nutrient deficiency identification	Reduce risk of crop damage
11. Compatibility of Pesticides during spraying	Reduce risk of crop damage and decreases the number of sprays.
12. Farm mechanization (seed to seed)	Reduce the input costs, labour wages and save the time
13. Maintenance of Drip system and developing of Fertigation	Reduce water requirement, enhances the nutrient use efficiency, increase productivity.

schedules for major crops in the district.	
14. On farm processing technologies for better remuneration	On farm processing or minimal processing fetches better price to farmers.
15. Grain Storage	Reduce the loss of grains due to various physical, Chemical, Biological or Physiological factors.
16. Backyard Kitchen Gardening and Backyard Poultry for balanced diet	Reduce the nutrient deficiencies in rural areas. Helps to augment income.
17. Safety Measures for use of Agro chemicals, Bio fertilizers	Reduce risk of health hazards
18. Modern Horticulture Practices (Staking, Mulching, Shade net, Polyhouses etc.	Growing Horticulture crops with modern technologies increases the productivity.
19. Knowledge on Bio fertilizers and Bio pesticides	Reduce the input costs and increases the productivity
20. Value addition to perishables	Reduces post-harvest losses and increases the income
21. Livestock Management	Increases the income and ensure the health of the animals

Appendix 3

Existing government schemes in Adilabad district

1. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)

The major objective of PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal waste water for peri-urban agriculture and attract greater private investment in precision irrigation system.
https://pmksy.gov.in/AboutPMKSY.aspx

2. Weather Based Crop Insurance Scheme (WBCIS)

Weather Based Crop Insurance Scheme (WBCIS) aims to mitigate the hardship of the insured farmers against the likelihood of financial loss on account of anticipated crop loss resulting from adverse weather conditions relating to rainfall, temperature, wind, humidity etc. WBCIS uses weather parameters as "proxy‟ for crop yields in compensating the cultivators for deemed crop losses. Payout structures are developed to the extent of losses deemed to have been suffered using the weather triggers.
https://www.india.gov.in/weather-based-crop-insurance-scheme-wbcis

3. Rainfed Area Development (RAD): under National Mission for Sustainable Agriculture (NMSA)

RAD will adopt an area-based approach for development and conservation of natural resources along with farming systems. This component has been formulated in a 'watershed plus framework', i.e., to explore potential utilization of natural resources base/assets available/created through watershed development and soil conservation activities/technologies under MGNREGS, NWDPRA, RVP&FPR, RKVY, IWMP etc. This component will introduce appropriate farming systems by integrating multiple components of agriculture such as crops, horticulture, livestock, fishery, forestry with agro based income generating activities and value addition. Besides, soil test/soil health card based nutrient management practices, farmland development, resource conservation and crop selection conducive to local agro climatic condition will also be promoted under this component. A cluster-based approach of 100 hectare or more (contiguous or non-contiguous in difficult terrain with close proximity in a village/adjoining villages) may be adopted to derive noticeable impact of convergence and encourage local participation and for future replication of the model in larger areas. Supplementary support from this component will be admissible for gap-filling resource conservation activities under converging programmes. RAD clusters should have soil analysis/soil health card/soil survey maps to justify the technologies proposed and at least 25% of the farming system area will have to be covered under on Farm Water Management.
https://nmsa.dac.gov.in/frmComponents.aspx

4. Pradhan Mantri Fasal Bima Yojana (PMFBY):

Pradhan Mantri Fasal Bima Yojana (PMFBY) aims at supporting sustainable production in agriculture sector by way of

- Providing financial support to farmers suffering crop loss/damage arising out of unforeseen events
- Stabilizing the income of farmers to ensure their continuance in farming
- Encouraging farmers to adopt innovative and modern agricultural practices
- Ensuring flow of credit to the agriculture sector which will contribute to food security, crop diversification and enhancing growth and competitiveness of agriculture sector besides protecting farmers from production risks.

https://pmfby.gov.in/

5. Mission Kakatiya

The objective of Mission Kakatiya is to enhance the development of agriculture based income for small and marginal farmers, by accelerating the development of minor irrigation infrastructure, strengthening community based irrigation management and adopting a comprehensive programme for restoration of tanks. https://missionkakatiya.cgg.gov.in/

6. Mission for Integrated Development of Horticulture (MIDH)

Mission for Integrated Development of Horticulture (MIDH) is a Centrally Sponsored Scheme for the holistic growth of the horticulture sector covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo. Under MIDH, Government of India (GOI) contributes 60%, of total outlay for developmental programmes in all the states except states in North East and Himalayas, 40% share is contributed by State Governments. In the case of North Eastern States and Himalayan States, GOI contributes 90%. https://midh.gov.in/

7. National Food Security Mission (NFSM)

In view of the stagnating food grain production and an increasing consumption need of the growing population, Government of India has launched this Centrally Sponsored Scheme, 'National Food Security Mission' in October 2007. The Mission met with an overwhelming success and achieved the targeted additional production of rice, wheat and pulses. The Mission continued during 12th Five Year Plan with new targets of additional production of food grains of 25 million tonnes of food grains comprising of 10 million tonnes rice, 8 million tonnes of wheat, 4 million tonnes of pulses and 3 million tonnes of coarse cereals by the end of 12th Five Year Plan. https://www.nfsm.gov.in/

Appendix 4

Existing policies implemented and funding arrangements (in Rs. Lakhs) at different blocks of Adilabad district:

Adilabad Blocks	Funds allotted through schemes in Lakh									
	PMKSY	WBCIS	NMSA	PMFBY	RKVY	MIDH	PMKSY	Mission Kakatiya	Telanganaku Haritha Haaram	Raising of Horticulture - Plantation Report (2018-2019)
Adilabad Rural	21.6	196.03		9.36	78.58	61.63	818	2629.79	0.12	0.13
Adilabad Urban		31.59		0.34				282.03		
Bazarhathnoor		175.74		1.93				3011.35		
Bela	7.85	412.87	21	15.67				1228.77	0.28	0.26
Bheempoor	22.85	273.73		7.52				806.02		
Boath	27.10	228.90		4.64				3734.13		
Gadiguda	21.85	15.34		0.08				1081.25		6.33
Gudihathnoor	24.60	127.93		4.02				1367.16		
Ichoda		129.27		9.98				1594.86	0.03	3.97
Inderavelly		82.19		2.12				1,605.57	0.76	4.02
Jainad	21.60 +20.35	454.79		58.62				1,796.70	1.10	0.4
Mavala		16.47		0.67				739.34		
Narnoor		74.46		1.18				228.77		9.86
Neradigonda	21.60	188.40		2.64				2,247.66		
Sirikonda		64.45		1.13				240.00		
Talamadugu	18.60	359.85		5.30				3,514.65		0.73
Tamsi		148.41		5.76				2,465.61		6.93
Utnoor	21.40	116.07	21	3.07				2,314.97	0.06	6.32
Total (Rs. lakh)	**250.00**	**3096.50**	**42.00**	**134.03**	**78.58**	**61.63**	**818**	**30888.63**	**2.74**	**38.94**

(Source: KVK, Adilabad)

Appendix 5

Adilabad district: Crops irrigated and un-irrigated area in *Kharif* and *Rabi* season

Average of latest 3 years (2016 to 2019)				
Season	**Crops**	**Irrigated, Ha**	**Un-irrigated, Ha**	**Total (Ha)**
Kharif	Cotton	15356	113904	129260
	Soybean	1027	30226	31253
	Jowar	0	3762	3762
	Green gram	0	1772	1772
	Black gram	0	2147	2147
	Red gram	2141	21400	23541
	Others	366	1038	1404
	Total (Ha)	**18890**	**174249**	**193139**
Rabi	Bengal gram	17268	3153	20421
	Wheat	1824	0	1824
	Jowar	2924	0	2924
	Maize	1123	0	1123
	Ground nut	977	0	977
	Sesame	198	0	198
	Others	1376	0	1376
	Total (Ha)	**25689**	**3153**	**28842**

(Source: KVK, Adilabad)

Appendix 6

Government support and farmer's contribution in total cost of project plan

CSA intervention	Total amount (Rs. Cr.)	Government support basis	Govt. subsidy (Rs. Cr.)	Farmers contribution (Rs. Cr.)
Water-Smart				
1. Farm Ponds	50.4	up to @ Rs. 75000/FP	37.8	12.6
2. Stop Dams and Check dams	25.0	100% govt. support	25.0	0.0
3. Drip Irrigation	125.0	35% Govt. subsidy	43.8	81.3
4. Mulching	6.0	50% up to Rs. 16000 per unit	3.2	2.8
8. Raised Bed Planting	7.4	Nil	0.0	7.4
9. Broad Bed Furrow (BBF) Planting	2.0	50% Govt. subsidy	1.0	1.0
Energy-Smart				
1. Minimum Tillage/Zero Tillage	0.2	Machinery and training provided by govt. centers	0.2	0.0
2. Solar Pumps	25.0	Govt. subsidy up to 1Lakh/unit	5.0	20.0
Nutrient-Smart				
1. Intercropping with Legumes	2.5	100% Govt. subsidy	2.5	0
2. Use of Farm Yard Manure	2.5	Nil	0.0	2.5
3. Fertigation	18.0	50% Govt. subsidy	9.0	9.0
Carbon-Smart				
1. Concentrate Feeding for Livestock	0.7	50% Govt. subsidy	0.4	0.4
2. Bio-gas	1.5	25% Govt. subsidy	0.4	1.1
Weather-Smart				
1. Climate Smart Housing for Livestock	2.5	50% Govt. subsidy	1.3	1.2
2. Information and Communication Technologies (ICT)	2.4	100% Govt. subsidy	2.4	0.0
Knowledge-Smart				
1. Fodder Banks	0.2	Nil	0.0	0.2
2. Stress Tolerant High-Yielding Breeds of Livestock	0.6	50% Govt. subsidy	0.3	0.3
3. Stress Tolerant High-Yielding Breeds of backyard poultry	0.8	50% Govt. subsidy	0.4	0.4
4. Knowledge on Bio fertilizers and Bio pesticides	0.1	100% Govt. subsidy	0.1	0.0
5. Livestock Management	0.1	100% Govt. subsidy	0.1	0.0
6. Crop diversification with fruits	0.1	100% Govt. subsidy	0.1	0.0
Total (Rs. Cr.)	**273.0**		**132.8**	**140.2**

Appendix 7

Year wise financial outlay planned

CSA intervention	Year 1	Year 2	Year 3	Year 4	Year 5	Total (Rs. Cr.)
Water-Smart						
1. Farm Ponds						37.8
2. Stop Dams and Check dams						25.0
3. Drip Irrigation and Fertigation						52.8
4. Mulching						3.2
5. Raised Bed Planting						0.0
6. Broad Bed Furrow (BBF) Planting						1.0
Energy-Smart						
1. Minimum Tillage/Zero Tillage						0.2
2. Solar Pumps						5.0
Nutrient-Smart						
1. Intercropping with Legumes						2.5
2. Use of Farm Yard Manure						0.0
Carbon-Smart						
1. Concentrate Feeding for Livestock						0.4
2. Bio-gas						0.4
Weather-Smart						
1. Climate Smart Housing for Livestock						1.3
2. Information and Communication Technologies (ICT)						2.4
Knowledge-Smart						
1. Fodder Banks						0.0
2. Stress Tolerant High-Yielding Breeds of Livestock						0.3
3. Stress Tolerant High-Yielding Breeds of backyard poultry						0.4
4. Knowledge on Bio fertilizers and Bio pesticides						0.1
5. Livestock Management						0.1
6. Crop diversification with fruits						0.1
Total (Rs. Cr.)	**46.4**	**44.8**	**29.7**	**8.4**	**3.5**	**132.8**